

APPENDIX Q

South San Francisco Bay Shoreline Study Existing
Biological Conditions Report (HT Harvey & Assoc. 2007)



**SOUTH SAN FRANCISCO BAY SHORELINE STUDY
EXISTING BIOLOGICAL CONDITIONS REPORT**

DRAFT

Prepared for:

**U.S. ARMY CORPS OF ENGINEERS
CALIFORNIA STATE COASTAL CONSERVANCY**

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ACRONYMS AND ABBREVIATIONS

CDFG	California Department of Fish and Game
CIR	Color infrared
ESU	Evolutionary Significant Unit
GIS	Geographic Information Systems
ISP	Interim Stewardship Plan
PG&E	Pacific Gas & Electric
PRBO	PRBO Conservation Science
SBSP	South Bay Salt Ponds
SCVWD	Santa Clara Valley Water District
MHW	Mean High Water
MHHW	Mean Higher High Water
MLLW	Mean Lower Low Water
SFBBO	San Francisco Bay Bird Observatory
SFBNWR	Don Edwards San Francisco Bay National Wildlife Refuge
USACOE	U.S. Army Corp of Engineers
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WPCP	Water Pollution Control Plant

1. EXECUTIVE SUMMARY

The San Francisco Estuary is an extremely productive, diverse ecosystem. Despite the loss of more than 90% of historic tidal wetlands in the Bay Area to diking, draining, and filling (Goals Project 1999), wildlife diversity is high, with more than 250 species of birds, 120 species of fish, 81 species of mammals, 30 species of reptiles, and 14 species of amphibians regularly occurring in the estuary (Siegel and Bachand 2002). More importantly, the San Francisco Bay supports populations of a number of species of regional, hemispheric, or even global importance. Numerous endemic, endangered, threatened, and rare wildlife species or subspecies reside in the San Francisco Bay Area.

The South San Francisco Bay (South Bay) is a vital component of the larger estuary. The South Bay supports some of the most important habitat remaining in the entire Bay Area for a number of wildlife species, in spite of the surrounding areas being highly urbanized and the Bay itself having been dramatically altered by the diking and filling of wetlands for salt production and urban development (Goals Project 1999).

This report characterizes the existing biological conditions related to the Shoreline Study which focuses on ecosystem restoration and flood damage reduction for the entire Study Area. The principal biological components of concern are the vegetation and habitats, and the wildlife. This report outlines the current state of understanding of these resources in the South Bay. The description of existing biological conditions is an important step in the early stages of planning as this description provides a foundation from which to evaluate and contrast a wide range of flood control and restoration alternatives, will serve to help inform the selection of the preferred alternative, and will provide baseline data for monitoring and adaptive management.

Habitats and Vegetation. The Shoreline Study Area (approximately 44,624 total acres) encompasses a variety of habitat types due to its land use history, its hydrologic placement within the landscape, and the extreme range of abiotic soil variables present within the area. Habitats vary from urbanized areas lined with concrete culverts to riparian fluvial drainages to freshwater, brackish, and salt marsh habitat. The dominant habitats that occur in the Study Area include approximately:

- 14,480 acres of developed area;
- 7498 acres of intertidal mudflat habitat (at -0.9 ft Mean Lower Low Water);
- 7135 acres of former and current salt production ponds;
- 3679 acres of wetland and riparian areas; and
- 2664 acres of open water/bay habitat.

Numerous occurrences of six special-status plant species, including Point Reyes bird's-beak, Hoover's button-celery, Congdon's tarplant, alkali milk-vetch, Contra Costa goldfields, and San Joaquin spearscale, have been documented in the immediate vicinity of the Study Area; the latter five species are known from the Study Area primarily from the Warm Springs Unit of the Don Edwards San Francisco Bay National Wildlife Refuge (SFBNWR) and the adjacent Pacific Commons Preserve in Fremont. Historical (likely

extirpated) populations of alkali milk-vetch and Point Reyes bird's-beak are documented in the vicinity of Alviso.

Wildlife Resources. This report includes discussions of the species composition and structure of invertebrate, fish, reptile, amphibian, mammal, bird, and plant communities in the South Bay. These species' life histories (as they pertain to their use of the South Bay), habitat requirements and habitat use in the South Bay, and the spatial and temporal variation in these species' presence/distribution in the region are summarized, as are the occurrence and use of the South Bay by special-status plant and wildlife species.

In summary, the ecology of South Bay wildlife communities is characterized by:

- High productivity of tidal marshes, with export of organic matter from tidal marshes to tidal sloughs, channels, and mudflats, and to the Bay, supporting high abundance of invertebrates, fish, and birds.
- High productivity of salt ponds and former salt ponds, supporting an abundance of invertebrates (particularly in higher-salinity ponds) and high numbers of fish in lower-salinity ponds, but with virtually no export of organic matter to other habitats aside from variable (and at times, very heavy) use of the salt ponds by birds.
- A heavily invaded aquatic invertebrate community dominated by non-native species, particularly in the estuarine and salt pond habitats.
- Heavy use of South Bay habitats by waterbirds, including significant proportions of Pacific Coast migratory shorebird populations.
- Highly dynamic bird and fish communities, with use of different areas varying several times a day with tide height, and with abundance and community composition varying seasonally depending on migration, precipitation, temperature, salinity, and other factors. In particular, large numbers of shorebirds forage on intertidal mudflats at low tide and use salt ponds and other alternative habitats (e.g., water treatment plant ponds) for roosting and/or foraging, particularly at high tide, and steelhead use bay habitats during their migrations as adults to spawn in tributaries and as juveniles moving from tributaries to the sea .
- The presence of rare San Francisco Bay endemics, including the California clapper rail and salt marsh harvest mouse, in remnant tidal marsh habitat.
- The presence of rare vernal pool-associated species, including the vernal pool tadpole shrimp and California tiger salamander, in vernal pools within the Warm Springs unit of the SFBNWR.
- The presence of several freshwater streams flowing into the South Bay; woody riparian habitat is limited to narrow corridors, or is highly degraded or even absent, along these streams, although moderately high-quality riparian habitat is present along lower Coyote Creek, and riparian habitats in the Study Area support very high densities of birds.

2. INTRODUCTION

This document describes the existing biological conditions of the South San Francisco Bay Shoreline (Shoreline Study) Study Area. The purposes of the Shoreline Study are to investigate the feasibility of a federally cost-shared project to meet the objectives of flood damage reduction, ecosystem restoration, and related purposes such as public access, and, if a potential project can be justified through existing Corps policy, to recommend such a project for Congressional authorization. An understanding of the existing natural landscape is necessary to accomplish these goals.

Other existing documents that are relevant to this report include the South Bay Salt Ponds (SBSP) Initial Stewardship Plan (ISP) (Life Science 2003), SBSP Biology and Habitats Existing Conditions Report (H. T. Harvey & Associates 2005), and the SBSP Draft Programmatic Environmental Impact Statement/Environmental Impact Report (PWA 2007).

To help guide the ecosystem restoration and flood protection aspects of the planning effort, the Shoreline Study will incorporate findings from the SBSP Restoration Project, a California Coastal Conservancy-led effort to restore historical wetlands on 15,100 acres of former salt-harvesting ponds in the South Bay. The U.S. Army Corps of Engineers (USACOE) and the Santa Clara Valley Water District (SCVWD) are active project management team members of the SBSP Restoration Project. Extensive coordination has occurred, and will continue to occur, between the Shoreline Study and SBSP projects.

This existing conditions report documents the current conditions within the Shoreline Study Area, including portions of this area that have not already been investigated for the SBSP Restoration Project. Therefore, in preparing this report, existing conditions information for the relevant portions of the SBSP project area were augmented by compiling information for the baylands area outside of the SBSP project area, but within the Alviso Ponds and Santa Clara County Interim Feasibility Study area, at the same level of detail as for the SBSP Restoration Project.

The existing biological conditions described in this document include habitat type, plant species composition, and potential wildlife use within the Shoreline Study Area at the onset of planning. This report contains the following sections:

Section 3. Habitats and Vegetation. Here, the existing conditions for habitats and vegetation in the Shoreline Study Area are presented, including an overall habitat assessment, the presence of non-native plant species, and the occurrence and potential for reintroduction of special-status plant species along with associated maps.

Section 4. Wildlife Resources. In this section, the existing conditions for wildlife in the Shoreline Study Area are documented. Included here are discussions of the composition and structure of invertebrate, fish, reptile, amphibian, mammal, and bird communities in the Study Area. Details of these species' life histories (as they pertain to their use of the South Bay), habitat requirements and use, and the spatial and

temporal variation in these species' distributions in the region are also included. Further, the occurrence and use of the Shoreline Study Area by special-status wildlife species is summarized.

2.1 Regional Setting

The San Francisco Estuary is an extremely productive, diverse ecosystem. Despite the loss of more than 90% of historic tidal wetlands in the Bay Area to diking, draining, and filling (Goals Project 1999), wildlife diversity is high, with more than 250 species of birds, 120 species of fish, 81 species of mammals, 30 species of reptiles, and 14 species of amphibians regularly occurring in the estuary (Siegel and Bachand 2002). More importantly, the San Francisco Bay supports populations of a number of species of regional, hemispheric, or even global importance. Numerous endemic, endangered, threatened, and rare wildlife species or subspecies reside in the San Francisco Bay Area.

The South San Francisco Bay (South Bay) is a vital component of the larger estuary. The South Bay supports some of the most important habitat remaining in the entire Bay Area for a number of wildlife species, in spite of the surrounding areas being highly urbanized and the Bay itself having been dramatically altered by the diking and filling of wetlands for salt production and urban development (Goals Project 1999).

The term "South Bay" is typically used to refer to the portion of the San Francisco Bay south of Coyote Point on the western shore of the Bay and San Leandro Marina on the eastern shore of the Bay (Goals Project 1999). This region differs in several physical and ecological aspects from the Central Bay, North Bay, San Pablo and Suisun Bays, and the Delta portions of the San Francisco Estuary. The Shoreline Study Area, for this existing conditions document, includes the open waters of the Bay up to the upper reaches of tidal action, the tidal and nontidal wetlands adjacent to the Bay, the former salt evaporation ponds adjacent to the Bay, the upland areas adjacent to and surrounding these features, developed areas, and the fluvial riparian inputs into the South Bay (Figure 1). This Study Area is bordered by the open waters of the South Bay to the northwest and by urban development on all other sides. While this Study Area is likely larger than what would be included in an actual Shoreline Study project, this landscape-level description of potentially impacted areas will be integral to the consideration of feasible restoration options and the concomitant benefits and impacts of those options.

2.2 Study Area

Broadly, the Study Area includes the Palo Alto/Mountain View area (south of San Francisquito Creek); Moffet Field, and the Alviso Ponds (and the areas inland to them) owned by the USFWS, SCVWD (Pond A4), and the City of San Jose (Pond A18) (Figure 1). It includes all of the Shoreline Study geographic area in Santa Clara County, as well as a small area in Alameda County that is part of the Coyote Creek/Mud Slough drainage from Santa Clara County. For aquatic Bay habitats, the Dumbarton Bridge is used as the northern boundary of the Study Area.

The Shoreline Study will focus on ecosystem restoration and flood damage reduction for the entire Study Area, though ecosystem restoration will most likely occur within the Alviso Ponds. The drainages in this

Study Area all flow through Santa Clara County and include: Coyote Creek/Mud Slough, Artesian Slough, Guadalupe River/Alviso Slough, Guadalupe Slough/Moffett Channel/Sunnyvale East and West Channels, Stevens Creek, Permanente Creek/Mountain View Slough, Charleston Slough/Barron Creek/Adobe Creek, and Matadero Creek/Mayfield Slough. The Study Area also includes the lower reaches of Laguna Creek and its watershed in Alameda County. The Alviso ponds occur at the base of several watersheds formed by the following drainages: Coyote watershed, Guadalupe watershed, San Tomas/Calabazas watersheds, Sunnyvale East/West watersheds, Permanente/Stevens watersheds, Adobe/Matadero watersheds and the San Francisquito watershed. Flood protection for San Francisquito Creek is being studied under separate authorization. San Francisquito Creek serves as the northern edge of the Study area, dividing the Santa Clara County and Alviso Ponds from San Mateo County and the Ravenswood Ponds.

3. HABITATS AND VEGETATION

3.1 Introduction

The Shoreline Study, which serves to identify and recommend for Federal funding one or more projects for flood damage reduction, ecosystem restoration and public access, serves as a complementary effort to the SBSP Restoration Project, a programmatic plan for habitat restoration, flood management and wildlife-oriented public access within former salt ponds of the South Bay. The physical boundaries of these two efforts overlap at the Alviso ponds and the open water/mudflats extending north to the Dumbarton Bridge, with the Shoreline Study Area reaching beyond the Alviso ponds into adjacent uplands. To describe existing conditions for habitats and vegetation in the Shoreline Study Area, an analysis of surrounding habitat types (Figure 1) was performed utilizing aerial mapping and site visits. This included a general habitat assessment, along with considerations for the potential occurrence and/or reintroduction of special-status plant species. The assessment of historical habitats in the Shoreline Study Area was also used to provide a baseline for the existing conditions of the ecological communities.

3.2 Methods

3.2.1 Base Imagery

All habitat mapping was rendered on IKONOS satellite imagery. The City of San Jose acquired the IKONOS imagery from a satellite pass that occurred at noon on 8 May 2004. The tidal elevation at this time was -0.9 feet Mean Lower Low Water (MLLW) near the mouth of Coyote Creek in the Alviso complex. The City of San Jose purchased the satellite images and subsequently donated them for use in the SBSP restoration planning. The 1-meter Multispectral (four-bands) CIR & True Color IKONOS satellite imagery is projected in UTM NAD83 (meters) Zone 10 North. Habitat mapping was based upon the imagery obtained and completed at a 1:2400 (1 inch = 200 feet) scale using the IKONOS imagery as a base layer.

3.2.2 Habitat Mapping and Area Calculations

Habitat mapping was completed using laptop computers (Panasonic Toughbook 18) equipped with GIS software (ArcView 9). The computers and software allow the IKONOS imagery to be used for mapping in the field or office.

Initial habitat boundaries and classifications using the IKONOS imagery were identified based on the signatures of the photographic imagery. Topographic features, marsh boundaries, and tentative habitat types (based on photographic signatures) were mapped in the office prior to field visits.

During the site visits in January 2007, extensive ground-truthing of those areas in the Shoreline Study Area that were not included in the original SBSP mapping was conducted. Marshes and riparian corridors were observed primarily from levee trails, unimproved salt pond levees, and Pacific Gas and Electric

(PG&E) walkways. The GIS database was downloaded and backed up weekly, and the digitized boundaries of habitat areas were reviewed for consistency and quality. Habitat acreages and color-coded figures for the entire Study Area were generated in GIS (ArcView 9.0).

3.3 Habitats and Vegetation

The Shoreline Study Area encompasses a variety of habitat types due to its land use history, its hydrologic placement within the landscape, and the extreme range of abiotic soil variables present within the area. Habitats vary from urbanized areas lined with concrete culverts to riparian fluvial drainages to freshwater, brackish, and salt marsh habitat. The Shoreline Study serves to analyze the unique demands placed upon this area of the Bay to balance urban demands for flood protection with restoration efforts and the needs of special-status plant and animal species.

3.3.1 Historical Habitats

The assessment of habitats that historically occurred along the South Bay provides a context in which to examine the existing conditions of South San Francisco Bay. Historical ecological communities of the South Bay are described in detail in the South Bay Salt Ponds Biology and Habitats Existing Conditions Report (H. T. Harvey & Associates 2005), Collins and Grossinger (2004), and Grossinger et al. (2006). Historically, the margins of San Francisco Bay were surrounded by a mosaic of wetland habitats, dominated by tidal salt marsh with large expanses of upland ecotones, intramarsh ponds, salt pannes, sinuous channel networks, beaches, lagoons, and sausals (Collins and Grossinger 2004).

Collins and Grossinger (2004) describe three major historical South Bay landscapes: saline tidal marsh, riparian tidal marsh, and salt pond. The South Bay saline tidal marsh landscape once consisted of marshlands with high channel density, abundant marsh pannes and salinas, moist grasslands along the backshore, large sausals, and extensive tidal flats. The South Bay riparian tidal marsh landscape existed along a salinity gradient from fresh to saline or brackish waters, influenced by perennial creeks such as Coyote Creek and the Guadalupe River. These areas had large marsh pannes and a less dense channel network in the vicinity of major freshwater sources. The South Bay salt pond landscape comprised tidal marshlands dominated by salt ponds. Native Americans developed these early ponds from salinas and marsh pannes by using low berms and weirs to control their hydroperiod. Tidal marsh and salt ponds were roughly equal in area, with minimal tidal channel network development. Small salinas and marsh pannes were adjacent to the salt ponds, with moist grasslands occurring along the backshore. Saltgrass-alkali meadow habitat existed in the complex transition zone between the tidal marsh and the wet meadows of the bottomlands of the South Bay. Unusually high concentrations of salt in alluvial soils created favorable conditions for unique plant communities with characteristics of high tidal marsh, alkali flats, and vernal pools (Grossinger et al. 2006).

Most of these historical communities have been greatly reduced in size due to land use changes in the South Bay, including residential development, agricultural use, salt production, and flood protection. More recently, South Bay marshes were significantly modified via diking to retain and concentrate Bay

water for salt production. Beginning in the mid- to late 1800's through the 1940's, levee construction led to the direct loss of tens of thousands of acres of tidal marsh in the South Bay (Collins and Grossinger 2004). Apart from these direct impacts, this construction led to dramatic changes in the physical processes influencing marsh development. By diking off these large expanses of marsh habitat, the tidal prism (volume of water that moves in and out of an area during a tidal cycle) was drastically reduced. The results of this decrease in tidal prism are still being observed in the South Bay, particularly in the Alviso pond complex (H. T. Harvey & Associates 2006).

3.3.2 Current Habitat Mapping Results

To generally assess existing conditions, broad-scale mapping for the Shoreline Study area included the Alviso pond complex, Moffett Field and the Palo Alto/Mountain View area south of San Francisquito Creek in Santa Clara County. In addition, a small area in Alameda County that is part of the Coyote Creek/Mud Slough drainage from Santa Clara County was also included in the Shoreline Study area. All habitats within the Shoreline Study Area were mapped at the scale shown in Figure 1.

During the mapping of the Shoreline Study Area, 25 different habitat categories were utilized. These habitat types included open water, mudflat, salt marsh, brackish marsh, freshwater marsh, riparian/creek corridor, muted tidal/diked marsh, active salt ponds, restored tidal salt ponds (under ISP Management)¹, seasonal ponds (under ISP Management), high salinity ponds (under ISP Management), system ponds (under ISP Management), seasonal ponds/high salinity ponds (under ISP Management), related projects (ponds), vernal pools, peripheral halophytes, landfill, water/sewage treatment, golf course, upland vegetation, parks/upland grassland, levee, airport, unvegetated, and developed (Figure 1). Each of these habitats is briefly described below, with survey results, and the locations of each habitat type are shown in Figure 1. It is important to note that small inclusions of differing habitat types may occur within a mapped section; however, these inclusions do not change the overall value or use of the habitat as described. For example, golf courses and/or airports probably contain areas of annual grassland or other such habitat types. Summary tables including all habitat types follow at the end of this section (Tables 1 and 2).

Open Water. Approximately 2664 acres of open water are found in the Study Area (Figure 1). The open waters of South San Francisco Bay, to the north of the Study Area, extend from a maximum depth of 25+ feet in the channel between the San Mateo and Dumbarton Bridges up to the MLLW elevation. However, water depth across the majority of the South Bay, particularly in the area southeast of the Dumbarton Bridge in the Study Area, is six to 12 feet deep or less. Open water exists along Mountain View Slough, Charleston Slough, Stevens Creek, Alviso Slough, Artesian Slough, Guadalupe Slough, and in Coyote Creek and extends into their corresponding drainages. The open water category includes a variety of habitat types, including subtidal Bay waters, tidal sloughs and channels, and areas of standing or flowing

¹ The Initial Stewardship Plan (ISP)(Life Sciences 2003) describes the operation and maintenance of the ponds prior to the long-term restoration plan and, as such the ISP represents the existing condition. Since the ISP implementation began in July 2004 and will continue to be implemented through 2007, assumptions have been made regarding biological functions and values that will be present once the ISP is fully operational, but prior to the implementation of the SBSP Restoration plan. The ISP will continue beyond 2007 for many ponds, until tidal restoration or managed pond condition is "implemented" in phases of the SBSP Restoration Project.

waters within all of the salt ponds as well as within tidal marshes. Despite lacking terrestrial or emergent vegetation, deep bays and channels support large aquatic invertebrates, fishes, waterbirds, and marine mammals and, in a few areas within the upper reaches of shallow bays, eelgrass (*Zostera pacifica*), an important submerged plant species.

Open water habitat that was mapped in detail occurs within the low-flow channel of adjacent creeks and slough channels that drain to the Bay, within the borrow ditches and former tidal meanders found within the salt ponds throughout the Study Area, and within the interior marsh ponds. The tidal sloughs and channels that carry water between and through salt ponds and marsh remnants provide important habitat for large numbers of benthic and pelagic invertebrates and fish. These detritus-rich channels serve as important nurseries and feeding areas for estuarine resident fish as well as migratory species such as the migratory life stages (adult, juveniles) of Central California Coast steelhead (*Oncorhynchus mykiss*), Chinook salmon (*Oncorhynchus tshawytscha*), and green sturgeon (*Acipenser medirostris*). Shorebirds, waterfowl, and other waterbirds utilize the channels and marsh ponds while the open waters of the Bay support a high diversity of benthic and pelagic macroinvertebrates. Piscivorous (fish-eating) birds such as the Forster's tern (*Sterna forsteri*), California least tern (*Sterna antillarum browni*), and double-crested cormorant (*Phalacrocorax auritus*) fly over open water in search of fish, while diving ducks such as greater scaup (*Aythya marila*), lesser scaup (*Aythya affinis*), canvasbacks (*Aythya valisineria*), and surf scoters (*Melanitta perspicillata*) dive in shallower water for bivalves, crustaceans, and other invertebrates. Only birds that can forage from the air (e.g., terns) or that are able to swim can exploit subtidal areas of the Bay, resulting in low bird diversity in the open waters. However, large densities of diving ducks occur in some areas where appropriate depths and concentrations of benthic invertebrates, particularly bivalves, provide a rich food source. Some wildlife species, such as gulls, also roost on the Bay, especially at night.

Mudflats. Approximately 7498 acres of intertidal mudflat habitat (based on the satellite imagery obtained during a -0.9 feet MLLW tide condition) are found in the Study Area (Figure 1). Mudflat habitat occurs in intertidal areas from below MLLW to Mean Tide Level (MTL) just beyond the edge of wetlands along the Bay and between the low-flow channel and edge of wetlands within the tidal reaches of slough and creek channels that drain to the Bay. Intertidal mudflats are expanses of unvegetated mud lying between MLLW and the lower marsh zone. These flats are generally covered by shallow water during high tide, but are uncovered at low tide. Narrow mudflats occur along the edges of the tidal sloughs and channels and on the outboard side of some salt pond levees, while much more extensive flats are present at the mouths of the major sloughs and along the edge of the Bay. Mudflats are dynamic depositional features, changing in extent and location depending on the nature of erosion and deposition of sediments.

Large expanses of newly formed mudflat habitat exist downstream of the Island Ponds (A19, A20, and A21), including a large, newly formed mudflat island at the mouth of Alviso Slough adjacent to Pond A9. Mudflat habitat also occurs at the mouth of Guadalupe Slough and along Charleston Slough and accreting mudflat occurs adjacent to Calaveras Point, the mouth of Mountain View Slough, and the mouth of Stevens Creek adjacent to Ponds A1 and A2W. Small areas of mudflat surrounded by open water are

adjacent to Pond A12. Additional small areas of mudflat are surrounded by freshwater marsh at the upper end of the reach of Coyote Slough to the south of the Island Ponds.

Mudflats are located on the bayside of ponds and provide important habitat for resident and migratory bird populations in the South Bay as well as foraging habitat for Bay fishes and invertebrates. Shorebirds, gulls, terns, American white pelicans (*Pelecanus erythrorhynchos*), and ducks often use exposed mudflats as roosting or loafing areas when they are available, as will Pacific harbor seals (*Phoca vitulina richardsi*).

This habitat typically supports less than 10% cover of vascular emergent vegetation, typically in the form of cordgrass (*Spartina* spp.) and annual pickleweed (*Salicornia europaea*) that is too sparse to map as distinct salt marsh habitat. The mudflat substrate comprises primarily fine-grained silts and clays that support an extensive community of diatoms, worms, shellfish, and algal flora. Inundated mudflats provide foraging habitat for many species of fish, and, during low tides, these mudflats additionally provide a primary food source for shorebirds.

High productivity of benthic invertebrates on mudflats is a result of nutrient availability resulting from detritus from tidal marshes, phytoplankton that settle in the water column, algae, and diatoms growing on the intertidal mudflats (Life Science 2003; Warwick and Price 1975). Crustaceans, polychaete worms, mollusks, and other invertebrates live on or just below the surface of the mud. During daily high tides, fish school over mudflats to feed on these invertebrates. As the tide recedes and the flats emerge, the fish retreat to subtidal areas while large numbers of birds, primarily shorebirds, leave their high-tide roosts to feed on the flats. These mudflats are primarily what make the San Francisco Bay Area important to West Coast shorebird populations; an average of 67% of all the shorebirds on the West Coast of the U.S. use San Francisco Bay wetlands (Page et al. 1999). Gulls and some dabbling ducks forage on the exposed mudflats as well. Because benthic invertebrates often recede deeper into the mud as the tidal elevation drops, especially large concentrations of foraging birds usually occur at the edge of the receding or rising tideline. Although the largest numbers of shorebirds forage on the broad flats along the edge of the Bay at low tide, some shorebirds, gulls, and large waders (e.g., herons and egrets) feed on the exposed flats along sloughs and channels. The smaller channels in the brackish and salt marshes are the favored foraging areas for the state and federally endangered California clapper rail (*Rallus longirostris obsoletus*).

Tidal Wetlands. For purposes of this study, tidal wetlands were divided into salt marsh, brackish marsh, and freshwater marsh. Although not fully tidal, muted tidal and diked marsh habitat is also discussed in this section. These habitats collectively account for the greatest acreage of vegetated habitat adjacent to the ponds, occupying 3419 acres of the surrounding habitat (Figure 1). Each of these distinct types of tidal wetland habitat is described in further detail, below. The tidal wetlands are mainly located in narrow strips between the mudflats and the Cargill and salt pond levees.

Salt Marsh. Approximately 725 acres of tidal salt marsh occurs on the outboard levees of the Study Area. Areas of tidal salt marsh in the South Bay are characterized by interstitial soil salinities greater than approximately 27 ppt, on average (H. T. Harvey & Associates 2002b). Salt

marsh habitat occurs primarily along the outboard (tidal) side of existing levees separating the salt ponds from the Bay. Salt marshes typically consist of three zones in the Bay: low marsh dominated by cordgrass, middle marsh dominated by pickleweed, and high marsh with a mixture of pickleweed and other moderately halophytic species that can tolerate occasional high tides.

The salt marsh habitat in the South Bay consists primarily of low and middle marsh and is dominated by pickleweed (*Sarcocornia pacifica*, formerly known as *Salicornia virginica*) and cordgrass. Pickleweed and cordgrass salt marsh habitats are separated by elevation; cordgrass typically occurs below the MHW mark and pickleweed occurs above the MHW, often extending up levee banks. Differences in pickleweed and cordgrass salt marsh habitat types also affect wildlife use and sedimentation in the slough and channels draining into the Bay.

There are two species of dominant cordgrass in the South Bay, the native Pacific cordgrass (*Spartina foliosa*) and smooth cordgrass (*S. alterniflora*), a non-native species from the east coast of North America. Smooth cordgrass can easily hybridize with the native cordgrass, causing widespread distribution of the hybridized species within a short amount of time. Smooth cordgrass and its hybrids are the predominant invasive plant species found in the tidal marshes south of the San Francisco Bay Bridge. In the Palo Alto Baylands, a survey conducted by the Coastal Conservancy's San Francisco Estuary Invasive Spartina Project from 2003 to 2006 showed an increase in the size of infestation from 0.61 acres spread over 49 patches in 2005, to 0.94 acres spread over 46 patches in 2006, a 54% increase (Porcella 2007). Total infestation of invasive cordgrass, based on both the SCVWD and Invasive Spartina Project's 2006 survey efforts, is estimated to be 18.9 acres spread amongst 286 patches. This is a 117% increase in acreage from 2005 to 2006 (Porcella 2007). Research has found that these infestations not only affect the foodweb, but that the smooth cordgrass and its hybrids grow lower into channels than the native cordgrass, which can reduce the extent of mudflat edge and possibly result in the loss of channels to vegetation encroachment and subsequent sedimentation (PWA and H.T. Harvey & Associates 2006). Current research and management programs on smooth cordgrass and its hybrids can provide guidance for salt pond restoration work (California State Coastal Conservancy and U.S. Fish and Wildlife Service 2003).

Other halophytic plant species commonly found in salt marsh habitat located within the South Bay include alkali heath (*Frankenia salina*), saltgrass (*Distichlis spicata*), saltmarsh dodder (*Cuscuta salina*), fleshy jaumea (*Jaumea carnosa*), spearscale (*Atriplex triangularis*), sea lavender (*Limonium californicum*), marsh gumplant (*Grindelia stricta* var. *angustifolia*), and the invasive perennial pepperweed (*Lepidium latifolium*). These species typically occur above the MHW mark in the high marsh zone, up to the ecotone between salt marsh and upland habitats. While these species usually occur in areas dominated by pickleweed, species such as marsh gumplant and perennial pepperweed sometimes occur in dense patches with less than 50% aerial coverage of pickleweed--areas assigned the *other salt marsh* classification. Areas with greater than 50% coverage of pickleweed, among any combination of other prevalent species, were classified as pickleweed salt marsh habitat.

Brackish Marsh. Approximately 955 acres of brackish marsh occur throughout the Study Area (Figure 1). This habitat covers the marsh plain in the transition from salt to brackish marsh along Coyote Creek, and also dominates the outboard levees near the junction of Mud Slough and Coyote Creek. Brackish marsh replaces salt marsh moving upstream along Guadalupe Slough, Alviso Slough, Mountain View Slough, and Stevens Creek.

Brackish marsh habitat typically occurs in the low-to-mid intertidal reaches of sloughs and creeks draining into the Bay where vegetation is subject to tidal inundation diluted by freshwater flows from upstream. As such, the average interstitial soil salinity of tidal brackish marsh is lower than in salt marshes, ranging from 15 to 20 ppt in the South Bay (H. T. Harvey & Associates 2002b). The water-surface elevation within reaches of brackish marsh in the Study Area (primarily located in the upper reaches of the Study Area) can vary by as much as ten feet, depending on daily tidal activity, seasonal freshwater flows from upstream, and their location within this estuary system.

The vegetation in brackish marsh habitat is dominated by emergent, vascular plant species adapted to intermediate (brackish) interstitial soil salinities including short bulrushes such as alkali bulrush (*Schoenoplectus robustus*, formerly known as *Scirpus robustus*) and saltmarsh bulrush (*Bolboschoenus maritimus*, formerly known as *Scirpus maritimus*). These species dominate lower brackish marsh habitat where sediment deposits have formed terraced floodplains between the low-flow channels and levees. The middle reaches of these channels are also dominated by shorter bulrushes, but in addition may have dense stands of tall bulrushes such as California bulrush (*Schoenoplectus californicus*, formerly known as *Scirpus californicus*) and hard-stem bulrush (*Schoenoplectus acutus*, formerly known as *Scirpus acutus*) adjacent to the low-flow channel of creeks and sloughs. Large, dense patches of invasive perennial pepperweed may also occur within terraced areas in middle reaches otherwise exclusively dominated by alkali bulrush. Other plants that can occur in brackish marshes include alkali heath, spearscale, and, along the high marsh/upland ecotone, pickleweed. Higher-order slough channels and upper-creek reaches dominated by these species may also be considered brackish marsh, depending on the extent of intrusion of fresher water in these areas.

Muted Tidal/Diked Marsh. There are a number of muted tidal/diked marsh areas occupying approximately 1250 acres in total in the vicinity of the Study Area, including New Chicago Marsh, the Palo Alto Flood Basin, and several smaller, adjacent areas (Figure 1). Muted tidal/diked marshes have limited tidal exchange due to the presence of levees around the perimeter of Bay waters/salt ponds. Water exchange is limited, so that the range in water level in the muted tidal marsh is small (usually a few inches) compared to the range of tidal change in other marsh areas (several feet). Muted tidal marshes exhibit many of the same features as fully tidal marshes, but they often have lower plant diversity due to the limited range in tidal action. The muted tidal and diked marshes in the Study Area represent the gradient from fresh to brackish to saline marsh habitat. For example, New Chicago Marsh is dominated by salt marsh, while the Palo Alto Flood Basin ranges from freshwater marsh habitat in the south to salt marsh habitat in the north.

Freshwater Marsh. Approximately 489 acres of freshwater marsh habitat occur throughout the Study Area (Figure 1). The majority of this habitat type is tidal freshwater marsh found in the upper reaches of Coyote Creek, Artesian Slough, Alviso Slough, and Guadalupe Slough where it transitions from brackish marsh. Freshwater marsh vegetation then extends from the upper reaches of Alviso Slough into the Guadalupe River and from the upper reaches of Guadalupe Slough into San Tomas Aquino and Calabazas Creeks. Freshwater marsh habitat typically occurs in the upper reaches of sloughs and creeks draining into the Bay. While these reaches may be subject to occasional tidal influence associated with high (usually spring) tides, and/or have somewhat saline historical sediments, these reaches are otherwise flushed with fresh water on a daily basis and therefore support mostly freshwater emergent vegetation. The water-surface elevation within reaches of freshwater marsh may also vary by as much as ten feet depending on daily tidal activity and seasonal, freshwater flows from upstream. Other non-tidal freshwater marshes are also present in the Study Area, including the Emily Renzel wetlands in Palo Alto.

Broad-leaf cattail (*Typha latifolia*) and taller bulrushes, including California bulrush and hard-stem bulrush, typically dominate the freshwater marsh habitat. Due to regular inundation, these species often form dense stands covering entire floodplain terraces along channels. Patches of perennial pepperweed and thickets of California blackberry (*Rubus ursinus*) also occur in regions of freshwater marsh.

Tidal marshes in the South Bay are remnants of their former extent, but support high densities of several wildlife species, including several San Francisco Bay endemic wildlife species. The state and federally endangered salt marsh harvest mouse (*Reithrodontomys raviventris*) and the salt marsh wandering shrew (*Sorex vagrans halicoetes*) occur in the salt marshes of the South Bay, particularly where pickleweed is present. The California vole (*Microtus californicus*) occurs here as well and is often the most common small mammal in tidal marshes. California clapper rails nest in cordgrass, denser stands of pickleweed, and marsh gumplant, particularly in the lower marsh zone where numerous small tidal channels are present, in both salt and brackish tidal marshes. The Alameda song sparrow (*Melospiza melodia pusillula*), endemic to the Central and South San Francisco Bay, nests in dense herbaceous vegetation in salt and brackish marshes as well, while the savannah sparrow (*Passerculus sandwichensis*) nests in pickleweed and peripheral halophytes in the upper marsh and upland transitional zones. The saltmarsh common yellowthroat (*Geothlypis trichas sinuosa*) nests in tidal and nontidal brackish and freshwater marshes, and possibly in low densities in salt marsh habitat as well (Ray 1919; Steve Rottenborn, pers. obs.), in the South Bay. Several species of ducks, and in a few locations herons and egrets, also nest in the tidal marshes of the South Bay (Gill 1977), and California black rails (*Laterallus jamaicensis coturniculus*) winter in small numbers in these marshes. Non-breeding birds, including larger shorebirds, swallows, blackbirds, and other species roost, occasionally in large numbers, in the tidal marsh, and tidal marshes (and mudflats) in several South Bay areas are used as haul-outs and pupping sites by harbor seals.

Riparian/Creek Corridor. Approximately 260 acres of fluvial riparian habitat and urban creek corridors are found throughout the Study Area (Figure 1). Riparian habitat is found along the upstream portions of

the majority of the drainages within the Study Area. Riparian habitat includes vegetation that occurs adjacent to freshwater streams, creek, and rivers. The historical riparian landscape found in the South Bay was characterized by perennial creeks that intersect the intertidal zone, producing brackish marsh at the interface with the saline landscape. Currently in the South Bay, riparian habitats that include large, mature riparian trees are limited to select portions of Coyote Creek and the Guadalupe River. Dominant canopy species in the South Bay include willow (*Salix* sp.) and Fremont cottonwood (*Populus fremontii*) while common understory species include elderberry (*Sambucus mexicana*) and wild rose (*Rosa californica*). Many of the creek corridors however, are concrete-lined channels with little to no woody vegetation and are confined by flood control levees.

Salt Ponds (Active and Inactive). Approximately 7612 acres of the Study Area are occupied by active and inactive salt ponds. Approximately 235 acres of Cargill-managed active salt ponds occur within the Study Area (Figure 1) represented by the southeast portions of salt ponds M4 and M5 which border the northern extent of the bayland boundary of the Study Area. The vast majority of salt ponds within the Study Area, referred to as the “Alviso salt ponds” and numbered A1 to A23 on Figure 1, are inactive, meaning that they have been taken out of salt production. These ponds were mapped and described according to their prescribed management regime, and encompass approximately 7377 acres. The salinity and hydrologic circulation regimes outlined in the ISP (Life Science 2003) result in five types of pond management systems: System, Full Tidal, High Salinity (Batch), Seasonal, and Mixed (e.g., Seasonal /High Salinity) Ponds. A sixth pond type, categorized under Related Projects and encompassing approximately 1436 acres, is not under a current management regime; the fate of these ponds is unknown at this time. Each of these pond types is described below:

System Ponds (ISP Management). The System Ponds, with approximately 4638 acres of salt ponds, are second only to mudflat habitat as the most abundant habitat found in the Study Area, and are by far the most extensive type of salt pond in the Study Area (Figure 1). They primarily occur along the east-west extent of the southern portion of the South Bay baylands, with two (Ponds A16 and A17) separated from the other System Ponds by the three high-salinity ponds. System Ponds are managed to have water circulating through a series of ponds linked by water control structures that are controlled to reduce or maintain ambient salinities. Management of these ponds under the ISP focuses primarily on meeting discharge requirements for salinity and dissolved oxygen; management for selected habitat conditions (e.g., shallow water for shorebirds, deeper water for waterfowl and diving birds) occurs as feasible while meeting water quality requirements.

Full Tidal Ponds (ISP Management). Approximately 477 acres of former salt ponds fully restored to tidal action occur within the three Island Ponds (A19, A20, A21), which are located between Coyote Creek and Mud Slough in the northern portion of the Alviso Pond complex (Figure 1). Levees were breached in March 2006 to allow full tidal action to be reintroduced to the pond.

High Salinity Ponds (ISP Management). Approximately 826 acres of high-salinity ponds (A12, A13, A15) occur within the east-central portion of the Study Area located between Coyote

Creek and Alviso Slough (Figure 1). High-salinity ponds are also referred to as batch ponds. This management strategy consists of a series of ponds, managed to maintain higher salinity levels to provide habitat for salt pond-associated bird species.

Seasonal Ponds (ISP Management). The two seasonal ponds (A22, A23) lie in the northern portion of the Alviso Pond complex and encompass approximately 712 acres (Figure 1). Seasonal ponds have no bay-water inputs; water levels rise and recede depending on precipitation and groundwater hydrology.

Seasonal Ponds/High-Salinity Ponds (ISP Management). Approximately 724 acres of seasonal/high-salinity ponds are located between the upper reaches of Alviso Slough and Guadalupe Slough in the pond complex (A8 North and South) and along the lower reach of Guadalupe Slough around the central portion of the Study Area (A3N) (Figure 1). These ponds are also referred to as mixed ponds. These ponds are managed differently at different times of the year, or managed adaptively.

Related Projects (Ponds). Approximately 1436 acres of former salt ponds in the Study Area, including Ponds A4 and A18 and the Crittenden Marsh area in the northern part of Moffett Field, are associated with related projects (Figure 1). Currently, the management plans for these ponds are actively being designed and future management of these ponds is uncertain. Future habitat enhancement options may include, but are not limited to, tidal restoration, managed pond, and diked or muted tidal wetland.

Generally, salt ponds in the South Bay are characterized by expanses of non-tidal open water, bare mud, or bare salt flats surrounded by mostly barren levees. Vegetation is sparse and where it does occur, it is limited primarily to levees. Due to the paucity of vegetation, salt ponds provide little to no cover for small mammals or reptiles, and provide nesting habitat only for species that nest on the bare levees and the occasional islands that have been created (by breaching of levees or deposition of material dredged from borrow ditches) within the ponds. Furthermore, much of the biomass produced by these ponds is unavailable to birds due to water depth and fish due to high salinity, which precludes these vertebrates' use of most of the invertebrates in the deeper, higher-salinity ponds.

At least 16 species of fish occur in the lower-salinity intake ponds, where they feed on an abundant supply of benthic and pelagic invertebrate prey. The native topsmelt (*Atherinops affinis*), longjaw mudsucker (*Gillichthys mirabilis*), staghorn sculpin (*Leptocottus armatus*), and non-native yellowfin goby (*Acanthogobius flavimanus*) and rainwater killifish (*Lucania parva*), are among the most common fish within these ponds (Takekawa et al. 2005). Because most of these fish cannot tolerate salinity > 70-80 ppt (Carpelan 1957; Lonzarich 1989), piscivorous birds in salt ponds generally forage only in the lower salinity intake ponds. Dabbling ducks are also usually present in highest concentrations in the lower salinity ponds, where they take both invertebrates and aquatic vegetation.

Salt ponds in the San Francisco Bay area provide habitat for more than one million waterbirds each year, including large percentages of the populations of some shorebird, duck, and tern species (Accurso 1992;

Harrington and Perry 1995; Page et al. 1999; Stenzel and Page 1988; Takekawa et al. 2001). Numerous waterbirds use the salt ponds and their associated islands and levees primarily for roosting, either at night or during high tide when their preferred foraging habitats are submerged. Large mixed-species flocks of shorebirds, gulls, terns, cormorants, pelicans, herons, and other birds are often seen roosting or loafing on levees, in shallow water, or on exposed mud in the ponds. A few species, including the black-necked stilt (*Himantopus mexicanus*), American avocet (*Recurvirostra americana*), western snowy plover, Caspian tern (*Sterna caspia*), Forster's tern, black skimmer (*Rhynchops niger*), California Gull (*Larus californicus*), and double-crested cormorant nest on islands or levees within the ponds, particularly those that are not accessible by mammalian predators, or in the case of the western snowy plover and California Gull, on barren salt flats on the bottoms of dried ponds.

The highest-salinity ponds support little, if any, wildlife. Above a salinity of 200 ppt, even brine shrimp cannot survive, and thus there is no prey to support predatory wildlife. Although birds may occasionally roost in these hypersaline ponds, the high salinity may have adverse effects on the birds, such as impairing the waterproofing of their feathers (Rubega and Robinson 1997), and little use is made of such ponds by wildlife (Takekawa et al. 2000).

Unvegetated Areas. Approximately 77 acres of unvegetated islands exist within several of the salt ponds (Figure 1). The majority of this acreage was mapped in ponds A6 and A2E. This habitat occasionally occurs on levee side slopes below approximately MHW. Unvegetated areas are typically confined to salt pond basins and consist of bare ground and salt flat areas. Most of the salt-pond basins were historically subject to regular tidal inundation and were vegetated with salt marsh species, but salinity resulting from their use as salt ponds over decades has resulted in conditions too saline to support even halophytic vegetation. While these areas typically lie below the MHW mark, they are no longer subject to tidal flooding.

Vernal Pool Grassland. There are approximately 481 acres of vernal pool grassland located in the northeastern portion of the Study Area in the Warm Springs area (Figure 1). Here, vernal pools occur within a grassland matrix, and no attempt has been made to map individual pools on Figure 1 or quantify their acreage. The vernal pool complex in the Study Area is adjacent to the backshore of historical tidal marshlands located near Warm Springs and consists mostly of small, distinct depressions among more diffuse swales. These vernal pools harbor the Contra Costa goldfields (*Lasthenia conjugens*) listed as endangered by the federal government. Upland grassland habitat containing vernal pool habitat is located landward from the salt ponds, between the salt ponds and urbanized areas.

Vernal pools are seasonally flooded depressions that occur on ancient soils that thinly cover an impermeable substrate of hardpan, clay, or bedrock above the tideline. The impermeable substrate causes the vernal pools to retain rainwater and local runoff seasonally, but to dessicate as evaporation drains their shallow topography. Because, vernal pools are essentially temporary wetlands, they undergo distinct vegetative phases: aquatic, flowering, and drought. During the aquatic phase of the vernal pool habitat, algae may flourish, along with the aquatic stages of coyote thistle (*Eryngium* sp.) and other vernal pool plant species. Later, after the winter rainstorms have ended, the pool will begin to dry and these plant species will flower, producing rings of color around the reducing pool, with the most water-tolerant

species occurring within the middle portions of the pool. During the drought phase, upland plant species may move into the vernal pool, resulting in an area that contains upland species, bare earth, dessicated hydrophytes, and residual algal matting during the late summer months.

Vernal pools in the Study Area provide important habitat for two rare wildlife species, the vernal pool tadpole shrimp (*Lepidurus packardii*) and California tiger salamander (*Ambystoma californiense*). These pools also provide seasonal foraging habitat for shorebirds, dabbling ducks, and egrets.

Peripheral Halophytes. Approximately 119 acres of peripheral halophytes are found along the banks and tops of levees surrounding the baylands and along the levees separating the salt ponds in the Study Area (Figure 1). The extent of peripheral halophytic vegetation is primarily determined by the salinity of the levee soils and how recently the levee soils were excavated from borrow pits in adjacent salt ponds. Peripheral halophytes typically include non-native, ruderal (“disturbance-loving”) species such as iceplant (*Mesembryanthemum nodiflorum*), New Zealand spinach (*Tetragonia tetragonioides*), Russian thistle (*Salsola soda*), and Australian saltbush (*Atriplex semibaccata*), which usually occur only above the MHHW mark. Native high marsh species also occasionally form peripheral halophytic habitat along levee banks as conditions permit. These species include marsh gumplant, alkali heath, spearscale, and saltgrass. In addition, pickleweed may occur on levee banks; assemblages of pickleweed and peripheral halophytes are mapped as salt marsh if pickleweed is dominant in the area. Low-lying, or eroded levees between salt ponds are usually too saline to support halophytes. Levees contiguous with uplands are typically dominated by upland species (described below) rather than peripheral halophytes.

Peripheral halophytes are used as foraging (and occasionally nesting) sites by ducks, song sparrows, and savannah sparrows, and provide foraging habitat and cover for several additional sparrows and finches during the nonbreeding season. In addition, peripheral halophytic vegetation provides important refugial habitat for salt marsh wildlife species during high tides.

Upland Vegetation/Golf Courses. There are approximately 1465 acres of upland habitat within the Study Area (mostly non-native grassland habitat), the majority of which consists of parcels of ruderal vegetation in the eastern and southern undeveloped portions of the Study Area (Figure 1). A small area of upland vegetation was also found bordering sections of freshwater and brackish marshes within the Study Area. In addition, 990 acres of golf course land, primarily within the southern extent of the Study Area, were identified.

Aside from numerous ornamental plant species occurring in landscaped areas, assemblages of annual, non-native plants that thrive in disturbed areas (ruderal species) dominate most of the upland habitat. These species include most tree, shrub, and herbaceous species found in upland areas. The predominant upland species surrounding the ponds include Italian ryegrass (*Lolium multiflorum*), ripgut brome (*Bromus diandrus*), black mustard (*Brassica nigra*), wild radish (*Raphanus sativus*), Mediterranean barley (*Hordeum marinum* ssp. *gussoneanum*), wild oats (*Avena fatua*), yellow star-thistle (*Centaurea solstitialis*), common sow thistle (*Sonchus oleraceus*), bull thistle (*Cirsium vulgare*), bristly ox-tongue (*Picris echioides*), rabbitsfoot grass, brass buttons, alkali heath, and coyote brush (*Baccharis pilularis*).

Most of the wildlife species found in peripheral upland areas are common species adapted to urban or ruderal habitats. Reptiles such as the western fence lizard (*Sceloporus occidentalis*), gopher snake (*Pituophis melanoleucus*), and southern alligator lizard (*Elgaria multicarantata*), and mammals such as the house mouse (*Mus musculus*), California vole (*Microtus californicus*), western harvest mouse (*Reithrodontomys megalotis*), California ground squirrel (*Spermophilus beecheyi*), black-tailed jack rabbit (*Lepus californicus*), cottontail (*Sylvilagus audubonii*), brush rabbit (*S. bachmani*), valley pocket gopher (*Thomomys bottae*), and striped skunk (*Mephitis mephitis*), all occur in the upland transitional areas along the edge of the Bay. A small, isolated population of western pond turtles (*Emys marmorata*) is present in brackish habitats near the Sunnyvale WPCP and Moffett Field, and California tiger salamanders occur in vernal pool habitats in the Warm Springs area.

In most areas, the bird species that occur in the peripheral habitats are also common, widespread species. These include permanent residents such as the Anna's hummingbird (*Calypte anna*), mourning dove (*Zenaidura macroura*), black phoebe (*Sayornis nigricans*), northern mockingbird (*Mimus polyglottos*), bushtit (*Psaltiriparus minimus*), California towhee (*Pipilo crissalis*), red-winged blackbird (*Agelaius phoeniceus*), Brewer's blackbird (*Euphagus cyanocephalus*), house finch (*Carpodacus mexicanus*), lesser goldfinch (*Carduelis psaltria*), summer residents such as the barn swallow (*Hirundo rustica*) and cliff swallow (*Petrochelidon pyrrhonota*), transients (some of which breed at higher elevations in the Bay Area), including the orange-crowned warbler (*Vermivora celata*) and Swainson's thrush (*Catharus ustulatus*), and winter residents such as the hermit thrush (*Catharus guttatus*), white-crowned sparrow (*Zonotrichia leucophrys*), golden-crowned sparrow (*Zonotrichia atricapilla*), yellow-rumped warbler (*Dendroica coronata*), and American pipit (*Anthus rubescens*). Burrowing owls (*Athene cunicularia*) are also present in ruderal habitats and non-native grasslands in scattered areas surrounding the South Bay salt ponds and marshes. The extent of the upland fields that once probably provided extensive alternate foraging habitat for shorebirds has been reduced considerably by development. Nevertheless, shorebirds such as killdeer (*Charadrius vociferus*), long-billed curlews (*Numenius americanus*), and dunlin (*Calidris alpina*) occasionally forage in more extensive upland fields in the Alviso, Fremont, and Newark areas during the wet season, and greater yellowlegs (*Tringa melanoleuca*) and least sandpipers (*Calidris minutilla*) may forage around ponded water in such fields in winter.

Parks/Upland Grassland. Approximately 466 acres of parks/upland grassland were found within the survey area, mostly located along the southern extent of the undeveloped portion of the Study Area (Figure 1). Included in this habitat description are areas within the Study Area designated as city or county parkland, including fallowed agricultural fields, manicured irrigation basins, and large areas of landscaped vegetation. Wildlife species in this habitat type are similar to those described for upland vegetation/golf courses above.

Levee. Approximately 416 acres of levees were mapped throughout the Study Area, found along the periphery of the baylands and separating many of the individual ponds in the salt pond complex (Figure 1). Levees are linear, barren, earthen structures that separate salt ponds from tidal areas and adjacent salt ponds. The levees in the South Bay salt pond complexes were typically constructed from soils excavated from borrow pits in former salt marshes which have since been developed into salt ponds; standing water can usually be found in the borrow ditches of otherwise empty salt ponds. The levee substrate is therefore

primarily saline, silty clay. Dirt roadways along the upland perimeters of salt ponds or bayfronts were typically mapped as levee. Portions of levees dominated by peripheral halophytes, or upland vegetation, were categorized as either of those habitat types, rather than as levee habitat.

Developed. Approximately 14,480 acres of developed areas make up the largest land use category within the Study Area. Development is found along the entire periphery of the Study Area boundary and extends towards the South Bay to the outward edge of the baylands (Figure 1). Approximately 1487 acres of lands designated for water/sewage treatment use are found in the Study Area. The majority of this acreage includes the water pollution control plants for the cities of San Jose and Sunnyvale. Approximately 779 acres of lands designated for landfill use are found in the including Newby Island, the Zanker Road Landfill, and Palo Alto Baylands. Approximately 975 acres of lands designated for airport use are found in the Study Area. Moffett Field makes up the majority of this airport designation.

Developed areas within each complex include roadways, parking areas, building complexes, pump facilities, water/sewage treatment areas, landfills, airports, and powerline facilities. Such areas are typically maintained free of vegetation, but may occasionally support isolated ruderal upland vegetation (described above). Larger areas of upland or ornamental (landscaping) vegetation in developed settings are categorized as parks/upland grassland. Sludge ponds, oxidation ponds, drying beds, and associated impoundments at the South Bayside System Authority Wastewater Treatment Works in Redwood City, the San Jose-Santa Clara WPCP in Alviso, and the Sunnyvale WPCP support high densities of breeding dabbling ducks, Canada geese (*Branta canadensis*), and black-necked stilts, and depending on pond conditions can support very high densities of migrant and wintering waterfowl.

Table 1 - Habitat Types mapped in the Shoreline Study Area (acreages).

Habitat Type	Acres
Muted Tidal/Diked Marsh	1250
Brackish Marsh	955
Salt Marsh	725
Freshwater Marsh	489
Riparian/Creek Corridor	260
Wetland/Riparian subtotal	3679
Mudflat	7498
System Ponds (ISP Management)	4638
Open Water	2664
Water/Sewage Treatment	1487
Related Projects	1436
High Salinity Ponds (ISP Management)	826
Seasonal Ponds/High Salinity Ponds (ISP Management)	724
Seasonal Ponds (ISP Management)	712
Full Tidal (ISP Management)	477
Salt Ponds (Active)	235

Habitat Type	Acres
Pond/Open Water subtotal	20,697
Developed	14,480
Parks/Upland Grassland	466
Airport	975
Upland Vegetation	1465
Landfill	779
Golf Course	990
Vernal Pool Grassland	481
Levee	416
Peripheral Halophytes	119
Unvegetated	77
Other subtotal	20,248
Total	44,624

Table 2 - Summary Table for the Habitat Types in the Shoreline Study Area.

Habitat Type	Acres	Proportion of Total
Wetland/Riparian	3679	8.2%
Pond/Open Water	20,697	46.4%
Other	20,248	45.4%
Total Area Mapped	44,624	100%

3.4 Special-Status Plant Species

Historically, special-status plant species were neither commonly occurring nor widely distributed within the upper zones of the tidal salt marsh and brackish marshes of the San Francisco Bay. However, those special-status species with broad edaphic tolerances were, and are today, locally common. For example, marsh gumplant (*Grindelia stricta* var. *angustifolia*), is limited to the upper marsh zone of the Bay, but tolerates disturbed fill soils; it is abundant within South Bay marshes and was recently removed from the California Native Plant Society (CNPS) Inventory of Rare and Endangered Plants (2001). Similarly, Congdon's tarplant (*Centromadia parryi* ssp. *congdonii*), while limited in distribution (CNPS List 1b), is associated with alkaline upper marsh habitats as well as with low-lying alkaline soils; large stands occur well east of the San Francisco Bay. Conversely, plants with highly restrictive growth requirements, such as for coarse substrates on high-energy shorelines, salt panne edges, or channel edges within tidal brackish marsh, are now extremely rare in the urban estuary of the Bay due to the limited acreage and distribution of these habitat types within the area. The continued persistence of these plants is further threatened by non-native, invasive plant species, particularly perennial pepperweed, which generally thrive under disturbed conditions with increased urban runoff.

3.4.1 Special-Status Plant Assessment

The California Natural Diversity Database (CNDDB, CDFG 2007) was queried to identify special-status plant species potentially occurring within the Palo Alto, Mountain View, and Milpitas USGS 7.5 minute quadrangles in which the majority of the Study Area occurs, as well as the ten quadrangles surrounding the Study Area, and the Newark and Redwood Point quadrangles that contain very small portions of the Study Area. In addition, to be inclusive of all species that may occur within the Study Area, particularly within grassland fringe areas with saline or alkaline soils, valley and foothill grassland, marsh and swamp, and vernal pool habitats were queried within the CNPS database (<http://cnps.web.aplus.net/cgi-bin/inv/inventory.cgi>, accessed 8 February 2007) for Alameda, San Mateo, and Santa Clara Counties.

Numerous occurrences of six species, including Point Reyes bird's-beak (*Cordylanthus maritimus* ssp. *palustris*), Hoover's button-celery (*Eryngium aristulatum* var. *hooveri*), Congdon's tarplant, alkali milk-vetch (*Astragalus tener* var. *tener*), Contra Costa goldfields (*Lasthenia conjugens*), and San Joaquin spearscale (*Atriplex joaquiniana*), have been documented in the immediate vicinity of the Study Area; the latter five species are known from the Study Area primarily from the Warm Springs Unit of the Don Edwards San Francisco Bay National Wildlife Refuge (SFBNWR) and the adjacent Pacific Commons Preserve in Fremont. Historical (likely extirpated) populations of alkali milk-vetch and Point Reyes bird's-beak are documented in the vicinity of Alviso. One additional species, Pacific cordgrass (*Spartina foliosa*), has been considered for inclusion in the USFWS draft recovery plan and is common in the area, but was not included in this assessment.

CNDDB (2006) records list 22 species as occurring within five miles (eight km) of the Study Area: San Joaquin spearscale, Congdon's tarplant, Contra Costa goldfields, alkali milk-vetch, hairless popcorn flower (*Plagiobotrys glaber*), robust spineflower (*Chorizanthe robusta* var. *robusta*), Hoover's button-celery, California seablight (*Suaeda californica*), arcuate bush mallow (*Malacothamnus arcuatus*), Point Reyes bird's-beak, slender-leaved pondweed (*Potamogeton filiformis*), lost thistle (*Cirsium praeteriens*), San Mateo thorn-mint (*Acanthomintha duttonii*), Marin western flax (*Hesperolinon congestum*), Franciscan onion (*Allium peninsulare* var. *franciscanum*), fragrant fritillary (*Fritillaria liliacea*), caper-fruited tropidocarpum (*Tropidocarpum capparideum*), western leatherwood (*Dirca occidentalis*), San Francisco collinsia (*Collinsia multicolor*), Hall's bush mallow (*Malacothamnus hallii*), most beautiful jewel-flower (*Streptanthus albidus* ssp. *peramoenus*), and Davidson's bush mallow (*Malacothamnus davidsonii*).

From this analysis, 49 special-status plant species have been identified that occur in similar Alameda, San Mateo, and Santa Clara county habitats and elevations, or are found within the USGS quads listed above, based on the query, including 22 special-status plant species that have been recorded within a five mile radius of the Study Area (CNDDB, CDFG 2007). All species selected from these queries were then cross referenced with the most recent state and federal listing update according to the California Department of Fish and Game to verify listing status and identify any recently listed species.

Presence of suitable habitat was the principal criterion used for inclusion in the list of species potentially occurring within the Study Area. Many of the special-status plant species that occur in Alameda, San Mateo, and Santa Clara Counties are associated with habitat or soil types that did not occur in the Study Area historically, or no longer occur in the Study Area due to the extensive removal of soil and addition of fill material. Following an analysis of the microhabitat conditions associated with these species, and the edaphic factors that favor their occurrence, 36 plant species of the original 49 are considered absent from the Study Area (Table 3a). The majority of the species were rejected for occurrence based on one or more of the following reasons:

1. The species would not occur within the Study Area due to the limited extent of degraded, upland habitat within the pond complexes or adjacent to developed areas and the highly saline and/or ruderal nature of these areas
2. The species occurs in chaparral habitat or cismontane woodland habitat, which do not exist within the Study Area.
3. The species nearly always or always occurs on serpentinite outcroppings, of which none were observed within the Study Area. Also, no serpentinite soil series are mapped in this area as being present by SCS (1968), and are not indicated as being present in the region by the Recovery Plan for Serpentine Soil Species of the San Francisco Bay Area.
4. The species' published elevation range is outside the range of elevations found along the Study Area.
5. The species has a highly endemic range that does not include areas within or reasonably near to the Study Area, or the species is considered by CNPS to be extirpated or absent from Alameda, Santa Clara, and San Mateo Counties

Table 3a - Plant Species considered, but rejected for occurrence within the South San Francisco Bay Shoreline Study Area (Santa Clara and Alameda Counties).

Scientific Name	Common Name	Lack of Chaparral or Other Suitable Habitat	Lack of Mesic Habitat	Lack of Serpentine Soils	Other Edaphic Factors Absent from the Site	Associated Species Absent from the Site	CNPS Records List the Species as Extirpated or Never Occurred	Suitable Habitat on Site Disturbed/Degraded
<i>Acanthomintha duttonii</i>	San Mateo thorn-mint	X		X			X	
<i>Allium peninsulare</i> var. <i>franciscanum</i>	Franciscan onion			X	X			
<i>Amsinckia lunaris</i>	bent-flowered fiddleneck	X						
<i>Atriplex cordulata</i>	heartscale				X	X		
<i>Atriplex coronata</i> var. <i>coronata</i>	crownscale		X			X		
<i>Atriplex depressa</i>	brittlescale		X			X		
<i>Centromadia parryi</i> ssp. <i>parryi</i>	pappose tarplant						X	
<i>Chorizanthe robusta</i> var. <i>robusta</i>	robust spineflower	X			X			
<i>Cirsium praeteriens</i>	lost thistle						X	

Scientific Name	Common Name	Lack of Chaparral or Other Suitable Habitat	Lack of Mesic Habitat	Lack of Serpentine Soils	Other Edaphic Factors Absent from the Site	Associated Species Absent from the Site	CNPS Records List the Species as Extirpated or Never Occurred	Suitable Habitat on Site Disturbed/Degraded
<i>Collinsia multicolor</i>	San Francisco collinsia	X		X				
<i>Cordylanthus maritimus</i> ssp. <i>palustris</i>	Point Reyes bird's-beak						X	
<i>Dirca occidentalis</i>	western leatherwood	X			X			
<i>Eriogonum truncatum</i>	Mt. Diablo buckwheat				X			
<i>Eryngium aristulatum</i> var. <i>hooveri</i>	Hoover's button celery					X		X
<i>Erysimum franciscanum</i>	San Francisco wallflower			X				
<i>Eschscholzia rhombipetala</i>	diamond-petaled California poppy					X		X
<i>Fritillaria liliacea</i>	fragrant fritillary			X				
<i>Hesperovax caulescens</i>	hogwallow starfish				X			
<i>Hesperolinon congestum</i>	Marin western flax	X		X			X	
<i>Hordeum intercedens</i>	vernal barley						X	
<i>Leptosiphon grandiflorus</i>	large-flowered leptosiphon							
<i>Lilium maritimum</i>	coast lily	X			X		X	
<i>Limnanthes douglasii</i> ssp. <i>sulphurea</i>	Point Reyes meadowfoam				X		X	
<i>Lotus formosissimus</i>	harlequin lotus	X			X		X	
<i>Malacathamnus arcuatus</i>	Arcuate bush mallow	X						
<i>Malacothamnus davidsonii</i>	Davidson's bush mallow	X					X	
<i>Malacothamnus hallii</i>	Hall's bush mallow	X						
<i>Microseris paludosa</i>	marsh microseris	X					X	
<i>Navarretia cotulifolia</i>	cotula navarretia				X			
<i>Perideridia gairdneri</i> ssp. <i>gairdneri</i>	Gairdner's yampah					X		X
<i>Plagiobotrys glaber</i>	hairless popcorn flower						X	
<i>Potamogeton filiformis</i>	Slender-leaved pondweed						X	
<i>Streptanthus albidus</i> ssp. <i>peramoenus</i>	most beautiful jewel-flower	X		X				
<i>Suaeda californica</i>	California seablite						X	
<i>Trifolium amoenum</i>	showy Indian clover			X			X	
<i>Tropidocarpum capparideum</i>	caper-fruited tropidocarpum						X	

The remaining 13 species considered for occurrence within the Study Area did not match any of the above rejection criteria, and could not be reasonably excluded due to the range of habitat types and ecotones present on-site; these species are considered in Table 3b. These include three species (Contra Costa goldfields, Congdon's tarplant, and prostrate navarretia) that are known to occur in the Study Area;

two species (San Joaquin spearscale and alkali milk-vetch) that are not known to occur in the Study Area but that occur immediately adjacent to the Study Area in the Pacific Commons Preserve, and thus have the potential to occur in the Study Area; one species (Delta tule pea [*Lathyrus jepsonii* var. *jepsonii*]) that is not known from extant occurrences in the South Bay but which could potentially occur in the Study Area; five species (palmate-bracted bird's-beak [*Cordylanthus palmatus*], hispid bird's-beak [*Cordylanthus mollis* ssp. *hispidus*], recurved larkspur [*Delphinium recurvatum*], Delta woolly-marbles [*Psilocarphus brevissimus* var. *multiflorus*], and saline clover [*Trifolium depauperatum* var. *hydrophilum*]) that are unlikely to occur in the Study Area; and two species (Mason's lilaeopsis [*Lilaeopsis masonii*] and Coastal Marsh milk-vetch [*Astragalus pycnostachyus* var. *pycnostachyus*]) that are considered absent from the Study Area, which probably has never provided suitable habitat for these two species. The ecology, distribution, and potential for reintroduction of these species are provided below.

Three terrestrial communities of concern appeared on CNNDB (2007) records within a five mile radius of the Study Area: Northern Coastal Salt Marsh, Serpentine Bunchgrass, and Valley Oak Woodland. Of these habitat types, only Northern Coastal salt marsh habitat occurs within the Study Area, as described above within the listed habitat descriptions.

Table 3b – Special-status plant species, their status, and potential occurrence in the Shoreline Study Area.

NAME	STATUS*	HABITAT/ DESCRIPTION	POTENTIAL FOR OCCURRENCE ON SITE
Federal or State Threatened or Endangered Species			
Palmate-bracted bird's-beak (<i>Cordylanthus palmatus</i>)	FE, SE, CNPS 1B	Chenopod scrub, Valley and foothill grassland/alkaline. Known from Alameda, Colusa, Fresno, Glenn, Madera, and Yolo Counties. Believed to be extirpated from San Joaquin County. Annual hemiparasitic herb that blooms May through October.	Unlikely. Due to the general degraded nature or lack of alkaline flat substrate within the Study Area, the occurrence of Palmate-bracted bird's-beak within the Study Area is unlikely.
Contra Costa goldfields (<i>Lasthenia conjugens</i>)	FE, CNPS 1B	Saline/alkaline vernal pools, mesic areas within grassland. Known from Alameda, Solano, Monterey, Contra Costa, and Napa counties. Annual; blooms March through June.	Present. Two large colonies associated with grassy seasonal wetlands in Fremont vicinity; otherwise occurs in disjunct populations in Monterey and North Bay. The Warm Springs portion of the Study Area provides suitable habitat and is included within the vernal pool critical habitat for Contra Costa Goldfields (Unit 8).
Mason's lilaeopsis (<i>Lilaeopsis masonii</i>)	SR, CNPS 1B	Exposed banks of tidal meanders and channels within brackish to freshwater marsh. Locally common in Suisun Marsh. Perennial; blooms April through November.	Absent. Not known to occur in the South Bay; historical and current records in Suisun Bay only.
State Rare and CNPS Species			
Coastal marsh milk-vetch (<i>Astragalus pycnostachyus</i> var. <i>pycnostachyus</i>)	FSC, CNPS 1B	Coastal salt marshes, streamsides, and mesic coastal dunes in Marin and San Mateo counties. Perennial; blooms April to October.	Absent. Not known to occur in South Bay; no suitable habitat in Shoreline Study Area (Extant populations associated with maritime salt marsh).
Alkali milk-vetch (<i>Astragalus tener</i> var. <i>tener</i>)	FSC, CNPS 1B	Alkaline soils in playas, vernal pools, and adobe clay areas within grassland. Alameda, Merced, Solano, and Yolo counties. Annual; blooms March to June.	Potential. Recently rediscovered in seasonal wetlands near Fremont, on Pacific Commons Preserve immediately outside Shoreline Study Area. Considered extirpated from Santa Clara County. Currently suitable vernal pool habitat occurs within the Warm Springs portion of the Shoreline Study area.
San Joaquin spearscale (<i>Atriplex joaquiniana</i>)	FSC, CNPS 1B	Alkaline soils within chenopod scrub, meadows, playas, and grasslands in 14 central California counties. Annual; blooms April through October.	Potential. Occurs in seasonal wetlands in Warm Springs vicinity; known from Pacific Commons Preserve. Potential habitat present in Warm Springs portion of Shoreline Study Area.
Congdon's tarplant (<i>Centromadia parryi</i> ssp. <i>congdonii</i>)	CNPS 1B	Moist, alkaline soils within grassland. Tolerates disturbance. Annual; blooms June through November. Known from Alameda, Monterey, San Luis Obispo, and Santa Clara counties.	Present. Occurs in seasonal wetlands in Warm Springs vicinity; known from Pacific Commons Preserve. Also recently recorded in Alviso and at Sunnyvale Baylands Park. May occur in peripheral halophyte or disturbed upland zones in Shoreline Study Area, but not currently associated with salt marsh.

NAME	STATUS*	HABITAT/ DESCRIPTION	POTENTIAL FOR OCCURRENCE ON SITE
Hispid bird's-beak (<i>Cordylanthus mollis</i> ssp. <i>hispidus</i>)	CNPS 1B	Meadows and seeps, Playas, Valley and foothill grassland/alkaline. Known from Alameda, Fresno, Kern, Merced, Placer, and Solano counties. Annual hemiparasitic herb that blooms June through September.	Unlikely. Due to the general degraded nature or lack of saline flats substrate within the Study Area, the occurrence of Hispid bird's-beak within the Study Area is unlikely.
Recurved larkspur (<i>Delphinium recurvatum</i>)	CNPS 1B	Chenopod scrub, Cismontane woodland, Valley and foothill grassland/alkaline. Known from Alameda, Contra Costa, Fresno, Glenn, Kings, Kern, Madera, Merced, Monterey, San Joaquin, San Luis Obispo, Solano, and Tulare Counties. It is believed to be extirpated from Butte and Colusa counties. Perennial herb that blooms from March through June.	Unlikely. Due to the general degraded nature or lack of grassland habitat with alkaline soils within the Study Area, the occurrence of recurved larkspur within the Study Area is unlikely.
Delta tule pea (<i>Lathyrus jepsonii</i> var. <i>jepsonii</i>)	CNPS 1B	High marsh zone in brackish and freshwater marshes. Known from Suisun Marsh (Sacramento, San Joaquin, Solano and Contra Costa counties) and Napa marshes. Perennial; blooms May through September.	Potential. Historical and current records are from the North Bay only. However, marginal habitat is present within the Study Area, and there is some potential for occurrence.
Prostrate navarretia (<i>Navarretia prostrata</i>)	FSC, CNPS 1B	Seasonal wetlands and vernal pools within grassland and coastal scrub. Known from Monterey County south to San Diego. Range Annual; blooms April through July.	Present. In South Bay, known only from Pacific Commons Preserve and the Warm Springs unit of the SFBNWR.
Delta woolly-marbles (<i>Psilocarphus brevissimus</i> var. <i>multiflorus</i>)	CNPS 4	Dried beds of vernal pools and flats, especially in grasslands, in Alameda and Santa Clara counties north to Yolo County. Annual; blooms April to June.	Unlikely. Currently the Warm Springs area presents potentially suitable habitat within the Shoreline Study Area.
Saline clover (<i>Trifolium depauperatum</i> var. <i>hydrophilum</i>)	FSC, CNPS 1B	Edges of salt marshes, alkali meadows, and vernal pools along the coast from Sonoma County south to San Luis Obispo, as well as in the inland counties of Solano and Colusa. Annual; blooms April through June.	Unlikely. Historical collection (type locality) from Belmont; not recorded since in South Bay. Currently the Warm Springs area presents potentially suitable habitat within the Shoreline Study Area.

CNPS LISTS:

- 1A – Plants presumed extinct in California
- 1B – Plants rare, threatened, or endangered in California and elsewhere
- 2 – Plants rare, threatened, or endangered in California, but more common elsewhere
- 3 – Plants about which more information is needed – a review list
- 4 – Plants of limited distribution – a watch list

Other Listed Status:

- FE –Federally Endangered
- FSC –Federal Species of Concern
- SR –State Rare
- SE –State Endangered

Palmate-bracted bird's-beak (*Cordylanthus palmatus*). **Federal Status: Endangered; State Status: Endangered; CNPS Status: List 1B.** Palmate-bracted bird's-beak is a hemiparasitic annual herb in the Scrophulariaceae typically found in chenopod scrub or alkaline valley and foothill grassland habitat at elevations of five to 155 meters. Plants are between ten to 30 centimeters, gray-green, and soft-hairy. Flowers are whitish and appear from May to October.

Palmate-bracted bird's-beak is known from only nine occurrences (CNPS 2001) and is threatened by agriculture, urbanization, grazing, and industrial development. No local occurrences exist in CNDDB records (2007). It is expected to occur within alkaline flats in the Study Area.

Potential for occurrence in the Study Area. Due to the general degraded nature or lack of alkaline flat substrate within the Study Area, the occurrence of palmate-bracted bird's-beak within the Study Area is unlikely.

Contra Costa goldfields (*Lasthenia conjugens*). **Federal Status: Endangered; State Status: None; CNPS Status: List 1B.** Contra Costa goldfields is a small, ephemeral annual sunflower typically occurring in mesic depressions within open, grassy habitats. Plants range in height from four to 12 inches and bear one to several flowerheads from March through June. Both ray and disk flowers are yellow. Contra Costa goldfields is distinguished from other common, co-occurring *Lasthenia* species by its lack of a pappus (an appendage arising from the ovary) on individual flowers.

Contra Costa goldfields occurs in 20 widely scattered populations in Alameda, Contra Costa, Mendocino, Monterey, Napa, and Solano Counties (CDFG 2004a). Extant populations in the South Bay area occur at the Pacific Commons Preserve (seasonal wetlands) and at the nearby Don Edwards San Francisco Bay NWR, Warm Springs Unit (vernal pools and swales). Management of both preserve areas focuses on the conservation of the species (USFWS and CDFG 2003; Wetlands Research Associates 1999).

Contra Costa goldfields is not expected to occur within tidal wetlands, but may occur in seasonal wetlands in the upland transition zone. According to the critical habitat designation for this species (Department of the Interior 2003), Contra Costa goldfields is most often found in vernal pools, swales, moist flats and depressions within grassland. However, Baye (2000) discusses the historical association of Contra Costa goldfields with saline seasonal wetlands at the marsh/upland boundary, as well as an apparent collection from a salt evaporator pond. Typical associated species include brass buttons (*Cotula coronopifolia*) and alkali heath, two common species of the upper and middle marsh, as well as the freshwater wetland species downingia (*Downingia* spp.), button celery (*Eryngium* spp.), water starwort (*Callitriche marginata*), and other species of goldfields (*Lasthenia glaberrima*, *L. fremontii*).

Potential for occurrence in the Study Area. Contra Costa Goldfields is present within the Study Area. Two large colonies associated with grassy seasonal wetlands occur in the Warm Springs unit of the SFBNWR. The Warm Springs portion of the Study Area provides suitable habitat and is included within the vernal pool critical habitat for Contra Costat Goldfields (Unit 8).

Mason's lilaeopsis (*Lilaeopsis masonii*). **Federal Status: Species of Concern; State Status: Rare; CNPS Status: List 1B.** Mason's lilaeopsis is a small, rhizomatous perennial in the carrot family (Apiaceae). Reaching heights of approximately three inches, plants form dense, turf-like colonies ranging from approximately 50 to over 7500 ft² (CDFG 2004a). Inflorescences of white or maroon flowers appear on short (≤ 1 inch), open umbels from April through November. Mason's lilaeopsis colonizes recently deposited, fine-grained soils on the edges of tidal meanders, sloughs, and saline-influenced reaches of creeks and rivers. This species is not known to occur in the highly saline environment of tidal salt marsh; rather, it favors the edges of marshes with significant fresh water inputs (i.e., the low brackish marsh zone). As such, populations are concentrated in the northern portion of the Bay, particularly in the Delta region, where large expanses of tidal brackish marsh occur.

Mason's lilaeopsis occurs on exposed tidal meanders and flats in the northeastern portion of the San Francisco Bay area. Associated species include marsh pennywort (*Hydrocotyle verticillata*), aquatic pygmy-weed (*Crassula aquatica*), tule (*Schoenoplectus californicus*, formerly known as *Scirpus californicus* var. *acutus*), and rushes (*Juncus* spp.) According to herbarium records catalogued by the University of California, the majority of reported occurrences of Mason's lilaeopsis are in San Joaquin, Sacramento, Contra Costa, and Solano Counties (CalFlora 2004). Although two Alameda County records exist, both apparently refer to a population south of Clifton Court Forebay at the Contra Costa County line (CalFlora 2004; CDFG 2004a).

Historically, creek flows into the South Bay were intermittent, and broad expanses of riparian vegetation and seasonal wetlands ringing the Bay retained runoff of rainwater prior to its reaching the marshes. Extremely high salinities at the edges of South Bay marshes are apparent in the historical distribution of salt pannes and natural salt ponds (San Francisco Estuary Institute 1999). Currently, salinity in the South Bay typically approaches that of seawater (Life Science 2004). This may account for the lack of historical records of Mason's lilaeopsis from the Alameda/San Mateo/Santa Clara counties region, although fringing brackish marshes do occur at Mud Slough, Coyote Creek, Artesian Slough, Alviso Slough, and Guadalupe Slough (Baye et al. 2000), and are currently increasing in extent (H. T. Harvey & Associates 1997b). Furthermore, extensive brackish marsh occurs at Petaluma Marsh, and Mason's lilaeopsis has not been documented there. Detailed studies of the distribution and abundance of this species are not available.

Potential for occurrence in the Study Area. Populations of Mason's lilaeopsis are absent from the South Bay, perhaps due to the lack of appropriate brackish habitat. Because Mason's lilaeopsis has never been documented in the Study Area, it is considered to be absent within the Shoreline Study Area.

Coastal marsh milk-vetch (*Astragalus pycnostachyus* var. *pycnostachyus*). **Federal Status: Species of Concern; State Status: None; CNPS Status: List 1B.** Coastal marsh milk-vetch is a stout, perennial herb in the pea family (Fabaceae) associated with maritime salt marshes, seeps, and mesic sites within dunes in Humboldt, Marin, and San Mateo counties. Plants have an open, clumping habit and are densely soft-hairy, with long pinnate leaves and distinctive papery, inflated fruits. Many greenish-white or cream colored flowers appear on in the axils of leaves from April through October.

Coastal marsh milk-vetch is known from three locations in coastal San Mateo County (Pescadero Marsh, Pomponio State Beach, San Gregorio State Beach), where plants are associated with sandy-clay or gravelly soils. Little published information is available on the ecological requirements of this plant, but suitable microhabitat apparently occurs within a range of plant communities. One population occurs on a steep slope within coastal scrub, associated with coyote brush (*Baccharis pilularis*), sea lettuce (*Dudleya farinosa*), and sticky monkeyflower (*Mimulus aurentiacus*). The Pescadero Marsh population, on the other hand, persists in a diked area with peripheral halophytes, including alkali heath and marsh gumplant. Approximately ten extant populations/occurrences are documented in Marin and Humboldt counties (CDFG 2004a), predominantly associated with the upper marsh ecotone. Coastal marsh milk-vetch's southern relative, Ventura marsh milkvetch (*A. p. ssp. lanosissimus*) is listed as endangered.

Potential for occurrence in the Study Area. Coastal marsh milk-vetch is found exclusively on coarse substrates such as sandy clay and gravel and has never been observed east of the immediate coast. Despite the relative tolerance of this species to disturbed habitats such as levees, it is considered to be absent from the Study Area due to historical and current patterns of sediment deposition. Furthermore, the Study Area is outside the known range of this species.

Alkali milk-vetch (*Astragalus tener* var. *tener*). Federal Status: None; State Status: None; CNPS Status: List 1B. Alkali milk-vetch is a delicate annual plant associated with vernal pools, alkaline flats, and vernal moist meadows and grasslands in Alameda, Merced, Napa, Solano, and Yolo counties. Plants range in height from two to 12 inches, appearing in late winter as erect or ascending stems with glabrous, pinnately compound leaves. Pinkish-purple flowers appear from March through June, depending on timing of soil saturation/inundation and drying. All taxa within this species complex are associated with moist, vernal mesic soils and are extremely rare.

Alkali milk-vetch is associated with seasonal wetland species such as owl's clover (*Orthocarpus* spp.), downingia, semaphore grass (*Pleuropogon californicus*), and popcorn-flower (*Plagiobothrys* spp.), and occasionally with peripheral halophytes such as salt grass and alkali heath, within alkali meadows. Plants occur on the upper edges of vernal pools, within grasslands underlain by heavy, moisture-retentive clay soils, and within the upper floodplains of rivers. Populations are often associated with, and threatened by, non-native annual grasses and forbs. At least one location, a population of alkali milk-vetch is threatened by management activities for waterfowl, which create perennially-inundated conditions unsuitable for supporting the species (CDFG 2004a). Approximately 30 extant populations/occurrences of alkali milk-vetch are documented by CDFG (2004a). The majority of these occurrences is the result of intensive surveys of historical locations, and is likely an accurate representation of the actual current range of the species.

Potential for Occurrence in the Study Area. Many historical locations of alkali milk-vetch in the South Bay (i.e., Alviso, Milpitas, and "Mayfield", now Palo Alto) are now heavily developed or degraded and, until recently, the species was presumed to be extirpated from the Bay Area. However, a population of alkali milk-vetch was discovered along the upper boundaries of created vernal pools at the Pacific Commons Preserve in 1999 (Wetlands Research Associates 1999). This population has persisted at least through 2006. This site is the location of a historical collection of the species, which likely persisted

through years of unfavorable conditions by remaining dormant in the seedbank. It is therefore possible that other sites along the outer edges of the baylands of the Study Area, particularly those within the marsh/upland transition zone, contain viable alkali milk-vetch propagules. Currently suitable vernal pool habitat occurs within the Warm Springs portion of the Shoreline Study Area.

San Joaquin spearscale (*Atriplex joaquiniana*). Federal Status: None; State Status: None; CNPS Status: List 1B. San Joaquin spearscale is an annual, grey-scaly, ascending plant in the goosefoot family (Chenopodiaceae). Like all *Atriplex* species, San Joaquin spearscale lacks petals, and flowers instead appear as dense clusters of fleshy, grey-green perianth parts in terminal inflorescences. This species flowers over a long period from April to October, depending on hydrological characteristics of the associated mesic habitat.

San Joaquin spearscale occurs on moist alkaline soils within a range of habitats, including non-native annual grassland, alkali meadow and scald, alkali sink, and the cut banks of eroded vernal pools. Huge populations occur in the vicinity of the Springtown Wetlands Preserve (in Livermore, CA, which is outside of the Study Area), most commonly associated with alkali heath, alkali weed (*Cressa truxillensis*), saltgrass, and tarweeds (*Centromadia* spp.) (Boursier 1997.). CDFG documents 69 populations/ occurrences of this species, nearly all of which were observed relatively recently and are presumed to be extant (CDFG 2004a).

Potential for Occurrence in the Study Area. San Joaquin spearscale, like alkali milk-vetch, was recently discovered growing along the margins of created vernal pools at the Pacific Commons Preserve in Fremont, adjacent to the Warm Springs Unit of the SFBNWR. Plants occur along the upper edges of created vernal pools, where they are associated with non-native grasses and forbs. No other occurrences are documented in the Study Area. Because the Pacific Commons population likely resulted from an existing seedbank, areas of suitable habitat in the Study Area may harbor dormant populations.

Congdon's tarplant (*Centromadia parryi* ssp. *congdonii*). Federal Status: None; State Status: None; CNPS Status: List 1B. Congdon's tarplant is a spiny, resinous annual herb in the sunflower family associated with moist, alkaline grasslands. Populations are frequently located within sumps or disturbed areas where water collects, and may be favored by moderate levels of disturbance that reduce the cover of non-native grasses and forbs. Unlike many of its community associates, this species matures in late summer and can flower into mid-fall; tarweeds in general are among the latest-blooming wildflowers of the area. Congdon's tarplant can be differentiated from co-occurring species of tarweed by the lack of tack-shaped glands on the leaves and flower bracts and the structure of its chaff scales (dry bracts among individual flowers).

Known populations of Congdon's tarplant occur in Monterey, San Luis Obispo, and Santa Clara counties, where CNNDDB documents 62 occurrences. Congdon's tarplant was once common along salt marsh edges in the South Bay (Munz and Keck 1959) and, as evidenced by recent observations of small, remnant colonies, has a slight potential for occurrence on levees and adjacent upland areas throughout the Alviso Complex. Associated species include Italian rye (*Lolium multiflorum*) alkali heath, and salt grass.

Potential for Occurrence in the Study Area. In the Study Area, several populations are known from disturbed annual grassland habitat in the vicinity of Alviso (H. T. Harvey & Associates 2002b; LSA Associates 1999), in the Warm Springs district of Fremont, near Milpitas, and in the Sunnyvale Baylands Park (CDFG 2004a). Congdon's tarplant has been reported from near the mouth of Stevens Creek, where a small, remnant occurrence of a historical population was observed in hard-packed gravel along the levee road north of the end of Crittenden Road (CDFG 2004a). Populations are also known from slightly saline grasslands in the Warm Springs district, and historical observations are reported from Cooley Landing in Menlo Park and from East Palo Alto (in the vicinity of the Ravenswood Complex). Congdon's tarplant is frequently associated with disturbed, alkaline habitats that pond water in the late winter and spring. As such, suitable habitat occurs on the margins of evaporation ponds or within the peripheral halophyte zone along the levees, and several occurrences are noted within the Study Area.

Hispid bird's-beak (*Cordylanthus mollis* ssp. *hispidus*). **Federal Status: None; State Status: None; CNPS Status: List 1B.** Hispid bird's-beak is a hemiparasitic annual herb in the Scrophulariaceae typically found in meadows and seeps, playas, or valley and foothill grassland habitats in alkaline soils at elevations of five to 155 meters. Plants are bristly and between ten and 40 centimeters, gray-green, often tinged purple, and long-non-glandular hairy. Flowers are whitish and appear from June to September.

Hispid bird's-beak is extirpated from much of the lower San Joaquin Valley (CNPS 2001) and is threatened by agricultural conversion, development, and grazing. No local occurrences exist in CNDDB records (2007). It is expected to occur within saline marshes and flats in the Study Area.

Potential for Occurrence in the Study Area. Due to the general degraded nature or lack of saline flats substrate within the Study Area, the occurrence of Hispid bird's-beak within the Study Area is unlikely.

Recurved larkspur (*Delphinium recurvatum*). **Federal Status: None; State Status: None; CNPS Status: List 1B.** Recurved larkspur is a perennial herb in the Ranunculaceae typically found in chenopod scrub, cismontane woodland, and valley and foothill grassland habitats in alkaline soils at elevations of three to 750 meters. Plants are between 18 and 85 centimeters, with flowers generally consisting of light-blue sepals and white petals, blooming from March to May.

Recurved larkspur is known from many historical occurrences (CNPS 2001), although much habitat has been converted to agriculture. It is also threatened by grazing. No local occurrences exist in CNDDB records (2007). It is expected to occur within poorly drained, fine, alkaline soils in grassland habitat in the Study Area.

Potential for Occurrence in the Study Area. Due to the general degraded nature or lack of grassland habitat with alkaline soils within the Study Area, the occurrence of recurved larkspur within the Study Area is unlikely.

Delta tule pea (*Lathyrus jepsonii* var. *jepsonii*). **Federal Status: Species of Concern; State Status: None; CNPS Status: List 1B.** Delta tule pea is a robust, climbing perennial plant in the Pea family (Fabaceae) associated with freshwater and brackish marsh. Plants often occur in large colonies, where

they are found twining through associated vegetation or as tangled masses; individual plants can reach six feet in length. Rose-purple flowers appear from May through June, after which plants gradually senesce to overwinter as underground rootstocks. Key characters distinguishing Delta tule pea from common taxa, include the co-occurring California tule pea, are compound leaves with elongated tendrils and ten to 16 leaflets, broadly-winged stems, and lack of hairs on the stems and leaves.

Populations of Delta tule pea are restricted to the edges of marshes and sloughs with significant freshwater inputs. Plants typically occur in relatively well-drained areas, often on slight topographic relief above the marsh plain (Baye et al. 2000), and are most frequently associated with cattail, bulrush, California rose (*Rosa californica*), and coyote brush (*Baccharis pilularis*). Several populations are associated with plants more typical of the high salt marsh, including saltgrass, pickleweed, and jaumea. The center of population distribution is in the Delta region, where plants may co-occur with other rare species such as Suisun Marsh aster (*Aster lentus*) and Mason's lilaeopsis. Delta tule pea is reported to occur in the vicinity of Niles in Alameda County, but is considered extirpated in Santa Clara County (CNPS 2001).

Potential for Occurrence in the Study Area: Although reportedly extant in Alameda County (CNPS 2001), no populations of Delta tule pea have been documented in the South Bay area (CDFG 2004a). Like Mason's lilaeopsis, Delta tule pea is associated with a brackish to freshwater marsh habitat that was never common in the Study Area and is considered to be absent from the area.

Prostrate navarretia (*Navarretia prostrata*). Federal Status: Species of Concern; State Status: None; CNPS Status: List 1B. Prostrate navarretia is a small annual herb in the Phlox family (*Polemoniaceae*) associated with vernal pools and mesic, alkaline areas within grassland. Plants have a stalkless, central flower head with many prostrate flowering branches spreading radially from beneath, and leaves are long, narrow, and deeply pinnately-lobed. White to violet flowers appear from April through July as dense clusters surrounded by spiny bracts.

Prostrate navarretia is associated with relatively coarse-grained sediments in small depressions within mesic areas. Associated species include the typical vernal pool indicator species coyote-thistle (*Eryngium vaseyi*), popcorn-flower (*Plagiobothrys* spp.), and spike rush (*Eleocharis macrostachya*). The majority of known populations of prostrate navarretia occur in southern California, where plants are associated with the large vernal pool complexes of the Santa Rosa Plateau, mima mound topography in Los Angeles County, and mesas south through San Diego. Significant populations also occur on military lands in southern Monterey County and at the Kesterson National Wildlife Refuge near Merced. In the South Bay area, prostrate navarretia is known only from the seasonal wetlands and created vernal pools at the Pacific Commons Preserve.

Potential for Occurrence in the Study Area: Populations of prostrate navarretia occur in the Study Area within the Warm Springs unit of the SFBNWR. This species is also present in the immediately adjacent Pacific Commons Preserve. Currently the Warm Springs area presents the only potentially suitable habitat within the Shoreline Study Area.

Delta woolly-marbles (*Psilocarphus brevissimus* var. *multiflorus*). **Federal Status: None; State Status: None; CNPS Status: List 4.** Delta woolly-marbles is an annual, vernal-pool endemic in the Sunflower family (Asteraceae) with silky-hairy foliage and several spreading stems from the base. Plants are grey-green throughout and produce small (less than 1 centimeter) oval heads of pale, cobweb-like flowers from May through June. Delta woolly-marbles occur along the drying edges of vernal pools within grassland.

Potential for Occurrence in the Study Area: Populations are not known, or expected, to occur in the Study Area. While vernal pool habitat occurs in the Study Area (e.g., in the Warm Springs unit of the SFBNWR) and its vicinity (e.g., in the Pacific Commons Preserve), none of these areas currently support populations of Delta woolly marbles. With no known seed source, it is highly unlikely that this species would naturally colonize the Study Area.

Saline clover (*Trifolium depauperatum* var. *hydrophilum*). **Federal Status: Species of Concern; State Status: None; CNPS Status: List 1B.** Saline clover is a very small, fleshy annual plant in the Pea family. Plants are decumbent to erect, with pink-purple, white-tipped flowers appearing from April through June. Flowers become inflated as fruits mature.

This species is associated with saline-alkaline soils within grasslands, seasonal wetlands, and, at Moss Landing in Monterey County, along the margins of upper salt marsh habitat. Throughout most of its known range, saline clover is associated with typical seasonal wetland plants such as meadow barley (*Hordeum brachyantherum*), semaphore grass, and downingia, or with alkali associations of brass buttons, saltgrass, and Italian rye. Populations near Moss Landing occur at the brackish marsh-grassland ecotone.

Potential for Occurrence in the Study Area. Historical records of saline clover from seasonal wetlands in the Belmont and Alameda areas document extirpated populations; and no extant populations are known from the South Bay area. While potential habitat is present in the Study Area, there are no known occurrences of the species in the vicinity. With no known seed source, it is highly unlikely that this species would naturally colonize the Study Area, despite the presence of suitable habitat.

3.4.2 Occurrence of Non-native Plant Species within the Shoreline Study Area

Research has shown that a number of variables control the distribution of plant species in coastal marshes, including depth and duration of flooding over the marsh surface (Mendelssohn and McKee 1988; Pennings and Callaway 1992; Webb and Mendelssohn 1996; Webb et al. 1995), accumulation of phytotoxins such as hydrogen sulfide in marsh soils (DeLaune et al. 1983; King et al. 1982; Koch and Mendelssohn 1989; Webb and Mendelssohn 1996; Webb et al. 1995), interstitial nutrient concentrations (Bradley and Morris 1990; Koch and Mendelssohn 1989; Koch et al. 1990; Morris 1980), and soil mineral and organic matter content (DeLaune et al. 1979; Nyman et al. 1990). Natural variability in abiotic factors such as precipitation, tidal fluctuation, and evapotranspiration, as well as anthropogenic changes to those factors such as freshwater discharges, non-point source pollution (nutrients and

sediments), and regional/global climate changes (drought, temperature, sea level) influence these variables (Boyer and Zedler 1999, Kennish 2001). Among these variables, hydroperiod and salinity are the primary abiotic factors that control the distribution of the dominant plant species in a tidal marsh (H. T. Harvey & Associates et al. 1982; Josselyn and San Francisco State Univ. 1983; Zedler et al. 1992; Zedler et al. 1999).

Competition between different plant species (interspecific) with similar environmental tolerances also influences their distribution. Although environmental tolerance and competitive ability are inversely related (Bertness 1991; Grace and Wetzel 1981; Zedler 1982), competition still plays a role among species with similar environmental tolerances (Ervin and Wetzel 2002). For example, Zedler (1982) found that competitive interactions occur in salt marshes, and concluded that pickleweed does compete with cordgrass for light and, to some extent, nutrients. Furthermore, competitive interaction is what allows for the successful invasion of non-indigenous species into wetland habitat and the subsequent alteration of plant distribution that is commonly observed (Vitousek 1990, Hooper and Vitousek 1997).

Many invasive plant species are known to occur or may potentially occur within the Shoreline Study Area. These species out-compete native plants, displacing entire communities of plants and associated wildlife. Control of these species is important throughout the Shoreline Study Area. While the scope of this analysis does not include a species-by-species prescription for removal, the California Invasive Plant Council (Cal-IPC) publishes the Weed Worker's Handbook (1994) describes the biology and tested methods of removal for 35 of the most noxious weeds in the Bay Area. The following species occur or may occur within the Shoreline Study Area: 1) Salt wheatgrass (*Agropyron elongatum*) has been planted along many levees to stabilize levee banks throughout the San Francisco Bay, and has spread in areas near Union City and along the levee slopes within the Palo Alto floodbasin; 2) Perennial pepperweed (*Lepidium latifolium*) has invaded many wetland areas within the San Francisco Bay, including areas within the Shoreline Study Area, but also occurs in upland areas with ruderal grassland habitat dominated by Italian ryegrass, various non-native bromes, Mediterranean barley, and wild oats; 3) black mustard (*Brassica nigra*) and wild radish (*Raphanus sativus*) dominate the banks of the levees within much of the Shoreline Study Area; 4) non-native smooth cordgrass (*Spartina alternifolia*) and hybrids between smooth and Pacific cordgrass have spread throughout tidal salt marshes in much of the San Francisco Bay area, and the Invasive Spartina Project is actively engaged in controlling this non-native; 5) pampas grass (*Cortaderia* sp.) occurs in ruderal areas including adjacent to developed areas; 6) French broom (*Genista monspessulana*) and Scotch broom (*Cytisus scoparius*) occur in upland, disturbed areas; 7) giant reed (*Arundo donax*) invades freshwater marsh and creeks; 8) sweet fennel (*Foeniculum vulgare*) spreads quickly within ruderal areas; 9) common reed (*Phragmites australis*) which may have strains that are not native to California and which has invaded portions of the Palo Alto Flood Basin; and, 9) yellow star-thistle (*Centaurea solstitialis*), purple star-thistle (*Centaurea calcitrapa*), and Italian thistle (*Carduus pycnocephalus*) quickly invade and dominate grassland areas. With the restoration of the SBSP areas and this Shoreline Study, documentation of infestation by non-native plant species should allow for better planning of the removal/containment of these species.

4. WILDLIFE RESOURCES

4.1 Introduction

The San Francisco Estuary is an extremely productive, diverse ecosystem. Despite the loss of more than 90% of its original wetlands to diking, draining, and filling (Goals Project 1999; Harvey et al. 1988), wildlife diversity is high, with more than 250 species of birds, 120 species of fish, 81 mammals, 30 reptiles, and 14 amphibians regularly occurring in the estuary (Siegel and Bachand 2002). More importantly, the San Francisco Bay supports populations of a number of species that are of regional, hemispheric, or even global importance. A number of endemic, endangered, threatened, and rare wildlife species or subspecies reside in the San Francisco Bay area.

Though surrounded by urban development and highly altered by the diking of wetlands for salt production, the South Bay supports some of the most important remaining habitat in the entire estuary for a number of special-status wildlife species. In this section, the existing conditions of wildlife resources in the South Bay are described, specifically pointing to the species composition and structure of invertebrate, fish, reptile, amphibian, mammal, and bird communities. The life histories and habitat requirements of these species are also described, as well as the spatial and temporal variation in their presence/distribution in the region. In addition, the occurrence of special-status wildlife species within the South Bay is summarized.

Slight variations in microhabitat conditions, plant structure, or species composition occur within the various habitat types of the South Bay (see Section 3.3). Such variations may result in important changes in ecological conditions that affect wildlife populations and communities. However, as they pertain to wildlife use of the Study Area, the previously described habitat types can generally be divided into several broad categories: open waters of the Bay, tidal sloughs and channels, intertidal mudflats, vegetated tidal marsh, salt ponds, vernal pool grasslands, riparian habitats, and upland habitats. Note that existing South Bay salt ponds (and former salt ponds) provide habitat that is used by large numbers of a number of wildlife species, particularly birds. Thus, in the descriptions of wildlife habitat use within Shoreline Study Area, salt ponds are included and the interchange that occurs between these and other habitats in the region is discussed. The freshwater stream, riparian, and vernal pool resources within the Study Area are also discussed.

4.1.1 Overview of Wildlife Resources in the South Bay

The ecology of South Bay wildlife communities is characterized by:

- High productivity of tidal marshes, with export of organic matter from tidal marshes to tidal sloughs, channels, and mudflats, and to the Bay, supporting high abundance of invertebrates, fish, and birds.
- High productivity of salt ponds and former salt ponds, supporting an abundance of invertebrates (particularly in higher-salinity ponds) and high numbers of fish in lower-salinity ponds, but with

virtually no export of organic matter to other habitats aside from variable (and at times, very heavy) use of the salt ponds by birds.

- A heavily invaded aquatic invertebrate community dominated by non-native species, particularly in the estuarine and salt pond habitats.
- Heavy use of South Bay habitats by waterbirds, including significant proportions of Pacific Coast migratory shorebird populations.
- Highly dynamic bird and fish communities, with use of different areas varying several times a day with tide height, and with abundance and community composition varying seasonally depending on migration, precipitation, temperature, salinity, and other factors. In particular, large numbers of shorebirds forage on intertidal mudflats at low tide and use salt ponds and other alternative habitats (e.g., water treatment plant ponds) for roosting and/or foraging, particularly at high tide, and steelhead use bay habitats during their migrations as adults to spawn in tributaries and as juveniles moving from tributaries to the sea.
- The presence of rare San Francisco Bay endemics, including the California clapper rail and salt marsh harvest mouse, in remnant tidal marsh habitat.
- The presence of rare vernal pool-associated species, including the vernal pool tadpole shrimp and California tiger salamander, in vernal pools within the Warm Springs unit of the SFBNWR.
- The presence of several freshwater streams flowing into the South Bay; woody riparian habitat is limited to narrow corridors, or is highly degraded or even absent, along these streams, although moderately high-quality riparian habitat is present along lower Coyote Creek, and riparian habitats in the Study Area support very high densities of birds.

In summary, the diversity and high productivity of habitat types present within the South Bay support a diverse assortment of wildlife species in surprisingly large numbers. A detailed discussion of the biology of wildlife species present within the Study Area is provided below.

4.2 Methods

Resource agencies such as the USFWS, CDFG, and the U.S. Geological Survey; non-profit organizations and research groups such as PRBO and SFBBO; consultants working for private landowners, municipalities, and public resource agencies; researchers; and private individuals (e.g., birders) together have collected a vast amount of data on wildlife use of the South Bay. Much of the data on the wildlife species and communities of the South Bay were summarized for the Goals Project (2000). In preparing this existing conditions document, the team relied primarily on previously collected information rather than fieldwork conducted specifically for the preparation of this document. However, the wildlife ecologists have a solid understanding of the wildlife and habitats of the South Bay during all seasons. Reconnaissance-level wildlife surveys by foot and car were performed during summer and fall 2004 for the existing conditions report for the South Bay Salt Ponds Project. H.T. Harvey & Associates ecologists have made numerous visits to the Study Area since that time, and additional surveys were conducted in March 2007 specifically to assess wildlife habitat in portions of the Shoreline Study Area outside the SBSP Project Area.

4.3 Description of Wildlife Communities in the South Bay

4.3.1 Invertebrates

Invertebrate communities of the South Bay are important consumers, controlling phytoplankton biomass in the Bay, and are key prey for fish and birds. They are also important in nutrient and contaminant recycling and the accumulation of contaminants (Thompson and Shouse 2004). Invertebrate communities vary considerably among different habitats in the South Bay. This section includes a separate description of invertebrates in subtidal/intertidal habitats, tidal marshes, salt ponds, terrestrial habitats, and freshwater habitats, as well as a discussion of invasive invertebrates and mosquitoes.

Subtidal/Intertidal Invertebrate Communities. Intertidal mudflats contain three main groups of invertebrates: benthic infauna (less mobile invertebrates living in or on the mudflats), epifauna (more mobile species on the mud's surface), and pelagic fauna (highly mobile species living in the water column). Most research has focused on benthic infauna. Because of the instability caused by nearly constant erosion and deposition of sediments, as well as dramatic fluctuations in salinity, benthic infauna are dominated by species that can easily colonize mudflats, many of which are non-native species (Nichols 1979). Within the San Francisco Estuary, the South Bay contains by far the highest invertebrate biomass, likely due to greater stability of salinity and sediments, large detritus biomass, and the abundance of several introduced bivalve species (Nichols 1979; Nichols and Pamatmat 1988). The estimated biomass of invertebrates in the South Bay in winter ($637 \text{ g}/0.1\text{m}^2$) and summer ($609 \text{ g}/0.1\text{m}^2$) is nearly six times that for the Central Bay, San Pablo Bay, and Suisun Bay combined ($115 \text{ g}/0.1\text{m}^2$ and $112 \text{ g}/0.1\text{m}^2$ in winter and summer, respectively) (Meiorin et al. 1991; Nichols and Pamatmat 1988). Studying infaunal productivity on mudflats in the South Bay, Nichols (1979) determined rates of annual productivity varying from 53 to 100 grams/meter²/year. Although biomass was dominated by two or three common bivalves, the standing crop of invertebrates was abundant throughout the year. Migratory shorebirds were thought to be the primary consumers of invertebrate biomass on South Bay mudflats.

Much of the food for benthic invertebrates on mudflats of the South Bay comes from phytoplankton that settle to the bottom of the water column (Meiorin et al. 1991) and diatoms and blue-green algae growing on the surface of the sediment (Nichols and Pamatmat 1988). Both phytoplankton and microalgae blooms occur in the South Bay primarily in spring, in turn supporting large numbers of filter-feeders (Nichols and Pamatmat 1988). The South Bay tidal invertebrate community is dominated primarily by filter/suspension feeders such as shrimp, clams, and mussels that obtain food from phytoplankton and organic debris and bacteria, and deposit feeders, which include worms and some clams that obtain food primarily from organic debris on the surface of the mud.

Several studies of the infaunal invertebrate communities of South Bay mudflats have been conducted. Nichols and Pamatmat (1988) and Nichols and Thompson (Nichols and Thompson 1985a; Nichols and Thompson 1985b) determined that the numerically dominant species on mudflats in the vicinity of the Alviso salt ponds are the gem clam (*Gemma gemma*), the amphipod *Ampelisca abdita*, and the polychaete

worm *Streblospio benedicti*. Although less abundant, the Baltic clam (*Macoma balthica/petulam*), soft-shelled clam (*Mya arenaria*), and eastern mud snail (*Illyanassa obsoleta*) “often represent the bulk of benthic invertebrate biomass” (Nichols and Thompson 1985a). All of these dominant species except for the Baltic clam are introduced.

The benthic infaunal community has been studied in the South Bay at three stations on intertidal mudflats near the Palo Alto Water Quality Control Plant since 1974 (Thompson and Shouse 2004). The number of invertebrate species at each of three stations ranged from ten to 16 and included five bivalves, one cnidarian, seven crustaceans, two gastropods, and 14 polychaetes and oligochaetes. *Gemma*, *Streblospio* and *Ampelisca* dominated the community until the 1980s, but since 1998 *Gemma* has been the overwhelming dominant on the Palo Alto flats. Since trace element concentrations at the plant were reduced in the mid-1980s, this research has noted a substantial decline in metals accumulation in the Baltic clam and an increase in the species’ reproductive activity (Hornberger et al. 2000).

Sampling nearby areas along lower San Francisquito Creek and the Palo Alto Water Quality Control Plant outfall channel, Cressey (1997) had somewhat different results. He found simple invertebrate communities in these areas, with the most abundant taxa consisting of four annelids (*Neanthes succinea*, *Eteoni lighti*, *Tubificidae* sp., and *Heteromastus filiformis*), three arthropods (*Nippoleucon hinumensis*, *Corophium alienense*, and *Grandidierella japonica*), and two mollusks (the Baltic clam and the Asian clam *Potamocorbula amurensis*); all except the Asian clam were found at all stations in both channels, in a variety of salinities from one to 27 ppt. The 1994-1996 Benthic Pilot Study of San Francisco Estuary Regional Monitoring Program (1997) found that in muddy estuarine sediments of the South Bay, the most abundant species were *Potamocorbula amurensis*, *Ampelisca abdita*, *Nippoleucon hinumensis*, *Corophium heteroceratum*, *C. alienense*, *Grandidierella japonica*, *Balanus improvisus*, *Tubificidae* sp., *Neanthes succinea*, and *Streblospio benedicti*.

More recently, the USGS sampled invertebrates in eight South Bay sloughs in 2004 (Takekawa et al. 2005). *Heteromastus*, *Streblospio*, and *Tubeficoidea* were the dominant taxa in these sloughs. The clam *Gemma gemma* was numerous in Mt. Eden Creek and Alameda Creek. *Macoma balthica* was present in all sloughs sampled. Low insect diversity was observed; insects were recorded in only three sloughs, with four species in Mt. Eden Creek representing the highest diversity in any of the sloughs sampled.

Bivalve mollusks, which represent the majority of the invertebrate biomass of the San Francisco Estuary (Nichols 1979), are primarily filter feeders, taking in large quantities of phytoplankton. A variety of clams and mussels, many of which are introduced, occur in the South Bay. Of the native species, the Baltic clam is the only one that is still common in the South Bay. The Baltic clam is the largest-bodied infaunal invertebrate in the South Bay and thus contributes significantly to the biomass of the region. It is eaten by birds (Painter 1966) and bat rays (*Myliobatus californica*) (Thompson and Shouse 2004) and likely by a number of other fish species as well. In the mid-1800s, the eastern oyster (*Crassostrea virginica*) and Pacific oyster (*C. gigas*) were introduced into San Francisco Bay, replacing much of the fishery for the native oyster (*Ostrea lurida*). Until around 1910, extensive oyster beds were located in the South Bay south of Dumbarton Bridge, and off Eden Landing and Redwood City. However, the introduced oysters declined in the early 1900s due in part to reduced Bay water quality; the loss of

marshes may have also influenced the decline in oyster populations, as much of the oysters' food is detritus that is derived from tidal marshes (Harvey et al. 1977). A native oyster bed was present in Salt Pond A-9 in Alviso until the 1970s (Laine, pers. comm.).

Thompson (1999), studying the spatial and temporal distribution of bivalves in the South Bay (primarily between the San Mateo and Dumbarton Bridges but with some stations scattered throughout the far South Bay, from 1991 to 1995), found that bivalves mostly disappeared from shallower areas in winter and spring; they declined in, but did not disappear from, deeper areas in winter. Recruitment varied among years, but was more likely to be limited in higher-elevation mudflats in some years than in deeper mudflats closer to channels, possibly due to predation by shorebirds and bat rays. Thompson and Shouse (2004) hypothesized that recruitment of bivalves onto South Bay mudflats where they are available to birds is dependent on the abundance of adult bivalves in deeper water and circulation patterns that transport larvae from either deeper water or from North Bay areas.

Tidal invertebrates in South Bay estuarine habitats must either be able to tolerate daily and seasonal changes in salinity (e.g., benthic invertebrates) or be mobile enough to follow preferred salinities. During particularly wet years, species intolerant of fresher water (e.g., *Mya arenaria*, *Corophium acherusicum*, *Ampelisca abdita*, and *Streblospio benedicti*) virtually disappear from portions of the upper San Pablo Bay and shallow areas of the Bay. During a two-year drought, these same species colonized Suisun Bay, which is usually too fresh for these species (Nichols and Thompson 1985a). Similarly, Hopkins (1987) noted that several intertidal invertebrate species disappeared during an unusually wet winter but had re-established the following year under normal conditions; two of his four intertidal study sites were near Palo Alto and Hayward. In contrast, limited observational data following unplanned breaches of Napa ponds 2a and 3, with releases of water having salinity of 50 and >60 ppt into South Slough, revealed no extensive losses of benthic invertebrates, suggesting that this elevated salinity did not have a significant impact on benthics.

The epifaunal invertebrate community in the South Bay is dominated by several species of shrimps and crabs. Two native caridean shrimps, the California bay shrimp (*Crangon franciscorum*) and blacktail bay shrimp (*C. nigricauda*), are common in tidal sloughs and in the Bay itself. The California bay shrimp supports the only commercial fishery remaining in the South Bay aside from the limited harvest of brine shrimp that occurs in salt ponds (as discussed below). Each year, two to four boats are involved in shrimping in the South Bay, catching approximately 75,000 lb valued between \$154K and \$312K per year (Hansen 2003), although shrimping activity and success have declined in recent decades (Laine, pers. comm.). Most shrimping activity occurs between the Dumbarton Bridge and Calaveras Point, with limited activity above Calaveras Point in Coyote Creek (Hansen 2003).

According to Hatfield (1985), adult California bay shrimp spawn in the ocean in March and April. The planktonic larvae are carried into the San Francisco Bay by tides, and by currents into the Suisun and South Bays. Juvenile bay shrimp arrive in the South Bay in May, and use shallow waters having lower salinities as nurseries. These juveniles migrate up sloughs to brackish water, seeking out waters with salinities of three to 19 ppt, preferring a range of ten to 15 ppt (Baxter et al. 1999). Thus, they use the Guadalupe, Alviso, and Coyote Slough systems, and likely other South Bay tributaries as well, for

feeding and growth through the summer. As they mature, the shrimp migrate to deeper, more saline Bay waters until they migrate out of the Bay to spawn in the ocean in winter (Baxter et al. 1999; Kinnetic Laboratories 1987). California bay shrimp are present in the South Bay year-round, but they are most abundant September-October and least abundant March-April (Hansen 2003). Bay shrimp are sensitive to changes in salinity and water quality, and may abandon sloughs in the far South Bay for deeper, more saline waters during periods of high freshwater runoff. Effluent from wastewater treatment plants may have altered the distribution of bay shrimp as well, as this species has declined in abundance in the far South Bay in recent decades (Laine, pers. comm.).

Crabs of South Bay tidal habitats include the yellow shore crab (*Hemigrapsus oregonensis*), lined shore crab (*Pachygrapsus crassipes*), Dungeness crab (*Cancer magister*), brown rock crab (*Cancer antennarius*), red rock crab (*Cancer productus*), and several introduced species, including the xanthid crab (*Rothropanopeus harrisi*), Chinese mitten crab (*Eriocheir sinensis*), and European green crab (*Carcinus maenas*) (Josselyn and San Francisco State Univ. 1983). Most of these species forage both in tidal sloughs and on mudflats and deeper waters of the South Bay. Although Dungeness crabs, and particularly larger individuals, occur much more commonly in the north and central Bay, this species was historically more common in the South Bay (i.e., into the 1970s) (Laine, pers. comm.). The *Cancer* crabs do not support a fishery within the South Bay, but use of South Bay marshes by juveniles of these species, and detrital export to the Central Bay from South Bay marshes, may help to support the economically important ocean fishery for these crabs. Crabs tagged as juveniles in the Bay have been caught by commercial fishermen in the ocean (Harvey et al. 1977). Furthermore, Dungeness crabs in the Bay mature nearly twice as fast as populations outside the Bay, presumably because of higher Bay water temperatures but possibly also due to the high productivity of the estuary (Life Science 2004). Early larval stages of the Dungeness crab are currently limited primarily to the Central Bay, but later planktonic larvae and juveniles may be found throughout the Bay (Life Science 2004).

The California Department of Fish and Game has conducted a fishery survey for shrimp and crabs within the San Francisco Bay since 1980, with monthly surveys in deeper subtidal areas and some beach seine sampling (CDFG data Life Science 2004). These surveys include data from three open-water stations (Stations 102, 101, and 140) located near the San Mateo and Dumbarton Bridges, and two beach seine stations (171 and 172) also located in the South Bay. Between 1980 and 2001, Dungeness crabs accounted for 52.6, 43.8, and 73.3% of crabs caught at Stations 101, 102, and 140. Chinese mitten crabs were 42.1, 12.5, and 18.8% of the total crab captures at these stations. Graceful rock crabs (*Cancer gracilis*) and brown rock crabs were, collectively, 18.8% of the total catch at Station 102 but <3% of the crab catch at the other two stations. California bay shrimp accounted for 79.5, 58.8, and 78.7% of shrimp captures at Stations 101, 102, and 140, while blacktail bay shrimp were 12.8, 34.2, and 14.0% of captures. Other shrimp species, including blackspotted bay shrimp (*Crangon nigromaculata*), oriental shrimp (*Palaemon macrodactylus*), stout coastal shrimp (*Heptacarpus brevirostris*), miniature spinyhead (*Mesocrangon munitella*), ridgetail prawn (*Exopalaemon carinicauda*), and visored shrimp (*Betasus longidactylus*), were all represented but were much less abundant in the South Bay.

Tidal Marsh Invertebrate Communities. The invertebrates of the vegetated portions of tidal salt and brackish marshes, which include benthic infauna, epifauna, and terrestrial species, have not received as

much study as those of intertidal habitats, in part because much of the invertebrate biomass within tidal marshes occurs within the intertidal and subtidal zones of sloughs and smaller marsh channels. However, tidal salt marsh invertebrates perform a variety of important ecological services, as discussed by Maffei (2000b).

Within tidal salt marshes in the South Bay, common invertebrates include the ribbed mussel (*Ischadium demissum*), the Baltic clam, the mud snail (*Illyanassa obsoleta*), and the yellow shore crab (*Hemigrapsus oregonensis*) (Niesen and Lyke 1981). The introduced ribbed mussel is common within the lower zone of tidal marshes (among Pacific cordgrass), and the Baltic clam may occur up into the cordgrass zone as well (Josselyn and San Francisco State Univ. 1983; Vassallo 1969). The native hornsnail *Cerithidea californica* formerly occurred in pickleweed marshes and on mudflats throughout much of the Bay, but it has been displaced from much of its former habitat and range by the introduced mud snail, and it is now restricted to high salt pannes in the South Bay (Race 1981). The mud snail is abundant in intertidal habitats and sloughs. The marsh snails *Assiminea californica* and *Ovatella myosotis* inhabit dense pickleweed marshes (Fowler 1977). Several amphipod species, including *Anisogammarus confervicolus*, *Orchestria traskiana*, *Hyale plumulosa*, and *Grandidierella japonica*, occur within the ground litter in pickleweed-dominated marshes (Josselyn and San Francisco State Univ. 1983). The amphipod *Traskorchestia traskiana* is abundant in at least some pickleweed marshes of the San Francisco Bay (Obrebski et al. 2000). This detritivore tolerates salinities up to 50 ppt (Koch 1989), and is one of the only invertebrates known to consume pickleweed (Page 1997).

Terrestrial invertebrate assemblages of salt marshes are dominated by a variety of insects and spiders. Diptera (true flies) are a major component of South Bay cordgrass/pickleweed marshes, while the orders Homoptera (plant hoppers and aphids) and Lepidoptera (butterflies and moths) are also well represented (Lane 1969). Reticulate water boatmen, brine flies, chironomid midges, and other species dominate open-water areas such as marsh ponds within the tidal marsh (Barnby et al. 1985; Maffei 2000b).

Detritus from macrophytic vegetation in the tidal marsh is an important component of the food web of the tidal marsh itself, as Teal (1962) demonstrated in Atlantic tidal salt marshes. Cameron (1972) determined that half of the detritus produced in San Pablo Bay marshes was exported out of the marsh, where it serves as an extremely important source of nutrients and carbon for the aquatic components of the Bay ecosystem (Harvey et al. 1977; Warwick and Price 1975).

Salt Pond Invertebrate Communities. Invertebrate communities in South Bay salt ponds have been extensively studied (Carpelan 1957; Anderson 1970; Swarth et al. 1982; Lonzarich and Smith 1997). Carpelan (1957), studied the floral and faunal communities in six Alviso salt ponds ranging in salinity from a mean of 27.5 ppt in the intake ponds to 94 ppt in the highest-salinity pond. Only one vascular plant species, wigeon grass, was present in this study; it only occurred one of the lower-salinity ponds for a brief period in mid-summer. Thus, the flora of the salt ponds is dominated by the macroscopic green algae *Rhizoclonium* and *Enteromorpha* in the lower-salinity ponds and by unicellular algae, particularly *Stichococcus bacillaris*, in higher-salinity ponds.

In salt ponds, invertebrate species richness decreases, and biomass increases (to a point) as salinity increases, primarily because of the increase in brine shrimp (Anderson 1970; Britton and Johnson 1987; Carpelan 1957; Lonzarich 1989; Swarth et al. 1982; Williams et al. 1990). In lower-salinity ponds, numerous nematodes occur in decaying organic matter and mud. The most prevalent worm in lower-salinity ponds is the polychaete *Polydora ligni*. This polychaete serves as prey for fish and the nemertinean *Tubulanus sexlineatus*, which is common in decomposing algae in the lowest-salinity ponds. Carpelan (1957) found few mollusks within the salt ponds. The introduced mud snail, which was abundant on the adjacent tidal mudflats, was found in scattered areas, although in its limited areas of distribution it was the dominant benthic species. Anderson (1970) reported that mud snails did not survive long in the Newark-area ponds he studied, and that although the ribbed mussel and native oyster were present in the adjacent slough, they did not become established in the intake ponds. A number of other non-arthropod species of varying abundance, including roundworms, rotifers, protozoans, and coelenterates, occur throughout the salt ponds (Anderson 1970; Carpelan 1957).

A survey of benthic invertebrates in Alviso salt ponds by Lonzarich (1989) found three mollusks (*Gemma gemma*, *Ilyanassa obsoleta*, and *Tryonia imitator*), two annelids (*Nereis succinea* and *Tubificoides* sp.), and six crustaceans (*Anisogammarus confervicolus*, *Crangon* sp., *Hemigrapsus oregonensis*, *Ostracoda* sp., *Palaemon macrodactylus*, and *Sphaeroma quoyana*) in ponds that seasonally reached salinities of 40 ppt, but not in higher-salinity ponds. Only the annelid *Polydora ligni* and the crustaceans *Artemia franciscana*, *Balanus* sp., *Copepoda* sp., and *Corophium* sp. tolerated salinities in the ponds that averaged 22-84 ppt.

Studying North Bay salt ponds, Takekawa et al. (2004) recorded 20 zooplankton taxa, with more taxa in lower-salinity ponds and highest abundance at mid-salinities. Copepods and brine shrimp accounted for 66.1 and 28.2% of all zooplankton sampled; copepods dominated low and mid-salinity ponds (23-48 ppt), while brine shrimp dominated higher-salinity ponds (170 ppt). Brine flies were also common in higher-salinity ponds. Total zooplankton abundance was highest in spring and early summer, with biomass several orders of magnitude higher in a pond having a salinity of 170 ppt than in lower-salinity ponds due to the abundance of brine shrimp. The diversity of macroinvertebrates was also higher in lower-salinity ponds (23 ppt), which contained 50-55 taxa (only three to four at high densities, including the polychaete *Heteromastus*, the bivalve *Gemma*, and the amphipods *Corophium* and *Ericthonius*). Mid-salinity ponds (48 ppt) contained 25 taxa dominated by the polychaetes *Polydora*, *Capitella*, and *Streblospio*, by *Corophium*, and by water boatmen, while a high-salinity pond (170 ppt) contained 12 taxa dominated by brine shrimp and brine flies.

Sampling of South Bay salt ponds between 2003 and 2005, Takekawa et al. (2005) recorded 58 taxonomic groups of macroinvertebrates. Crustaceans were the best represented group, with 17 taxa, followed by 12 annelid taxa; these taxa were predominantly in lower-salinity ponds (i.e., below 60 ppt). Five species of bivalves and nine insect families were also recorded, with overall taxa richness occurring in the ponds with the lowest salinity (27-44 ppt).

Arthropods are the dominant, and ecologically most important, group of invertebrates inhabiting salt ponds in the South Bay. The brine shrimp (*Artemia franciscana*) is the predominant animal in higher-

salinity ponds. Although it can occur in salinities near that of seawater (Persoone and Sorgeloos 1980), the brine shrimp's aquatic predators (e.g., insects such as water boatmen) are more abundant in less saline water (Wurtsbaugh 1992), allowing brine shrimp to reach high densities only in their optimal hypersaline environments (70 to 170 ppt) (Carpelan 1957). Herbst (2001) found water boatmen to be most abundant in lower-salinity ponds while brine shrimp were most abundant in moderate to high salinity salt ponds in the Mojave Desert. Brine shrimp are absent from crystallizer ponds with salinities exceeding 200 ppt (Larsson 2000). Historically, brine shrimp occurred in the San Francisco Bay area in salt pannes and ponds with hypersaline conditions. They still occur in these natural features within tidal salt marshes in the South Bay, in addition to salt ponds.

Carpelan (1957) estimated that brine shrimp in the Alviso salt ponds produced up to eight generations/year, with winter eggs having delayed hatching. Larsson (2000) reported that females produce an average of ten broods during their 50-75 day lifespan in the lab, although under natural conditions three to four broods may be more likely. Productivity of brine shrimp in the highest-salinity pond in Carpelan's study area was estimated at 56 lb/acre/year. Brine shrimp are so abundant in some ponds that they have supported a small commercial industry, primarily as food for aquarium fish. According to Thomas Laine (pers. comm.), these shrimping operations can regularly obtain 10,000-13,000 lb of shrimp per day, with two people once collecting 27,000 lb in a day in South Bay ponds, and a 42-day operation netting 500,000 lb of brine shrimp in South Bay salt ponds. Brine shrimp are still harvested in Newark salt ponds, where they fetch \$0.55/lb (Laine, pers. comm.).

Two insect groups are also important components of the South Bay invertebrate fauna due to numerical abundance and importance to foraging birds. Adult reticulate water boatmen inhabit salt ponds year-round. Carpelan (1957) found that egg-laying occurs in spring, summer, and fall, with the main hatch in spring; many nymphs are observed in April and May. Water boatmen have been reported to occur in water ranging from brackish to 170 ppt (Carpelan 1957; Cox 1969; Jang 1977), and Carpelan (1957) found them in Alviso salt ponds with salinities from 23 to 153 ppt. However, they occur and reproduce in greatest abundance in ponds with salinities between 35 and 80 ppt (Maffei 2000c). A number of species of brine flies occur within the San Francisco Bay area; the most common species within the Shoreline Study Area are *Ephydra millbrae*, *E. cinerea*, and *Lipochaeta slossonae*, which occur in variable numbers in natural salt pannes and marsh ponds, and in artificial salt ponds and crystallizers (Carpelan 1957; Maffei 2000b). *E. millbrae* has been reported to occur in pools with salinity concentrations up to 42 ppt (Jones 1906), while *E. cinerea* and *Lipochaeta slossonae* occur in saline and hypersaline environments, with *Lipochaeta* found commonly in crystallizers (Maffei 2000a). Even as adults, water boatmen are primarily aquatic, although they can fly. In the South Bay, adult brine flies become common by early March and can be seen in dense swarms on the edges of high-salinity ponds from April through September (Swarth et al. 1982).

The biomass of brine shrimp in South Bay salt ponds may be four times that of water boatmen (Swarth et al. 1982), and brine shrimp have been found to be a numerically important component of the diet of the western sandpiper, Wilson's and red-necked phalaropes, and other waterbirds (Anderson 1970; Colwell and J.R. Jehl 1994; Hamilton 1975; Harvey et al. 1992; 1988; Jehl 1988). Despite the high biomass of brine shrimp in salt ponds, the nutritive value of brine shrimp to foraging shorebirds may be limited, as

Rubega and Inouye (1994) found that red-necked phalaropes could not survive foraging on brine shrimp alone. As a result, brine flies (both adults and larvae) and reticulate water boatmen are also very important to shorebirds that forage in mid- to high-salinity South Bay salt ponds. Amphipods, most notably *Corophium* spp., are numerous in South Bay salt ponds as well (Carpelan 1957), serving as additional prey items important to shorebirds and fish.

Freshwater Macroinvertebrate Communities. Stream macroinvertebrate communities are structured largely by physical factors, such as temperature, light, current velocity, and substrate composition, and chemical factors, such as oxygen levels, pH, nutrients, and chemical pollutants. These communities are comprised of a diverse array of species that can generally be grouped into functional assemblages based on their feeding mechanisms and the roles that they play in stream ecology. Within a given taxonomic group, different species often assume different ecological functions and feeding preferences.

Collectors and filterers include certain decapods (freshwater crayfish), or larvae of some tricopterans (caddisflies), plecopterans (stoneflies), ephemeropterans (mayflies), and others. Many of these species filter fine particulate organic matter directly from the water column; and members of this functional group typically dominate invertebrate communities in larger-order, lower-gradient streams because of the high concentrations of particulate detritus suspended within the water column within these river mouth habitats. Representative South Bay groups include larval common midges (*Chironomus* sp., Diptera:Chironomidae) which are abundant filterers of living phytoplankton from the water column, and leptocerid caddisflies (Trichoptera:Leptoceridae), which are indiscriminant detritus feeders that are common in ponds and slow-moving river mouths.

Grazers can include large invertebrates such as gastropods (freshwater snails), or larval insects such as other species of caddisflies and nematoceran true flies. These groups are more prevalent in open areas with ample light and substantial algal growth, such as mid-order riverine systems and open ponds. Common Bay Area groups include the northern snailshell caddisfly (*Helicopsyche borealis*, Trichoptera:Helicopsychidae), which actually constructs a larval case that looks like a snail's shell. Larval psycodid gnats such as the lance-winged moth fly (*Maruina lanceolata*, Diptera: Psychodidae) are frequently found in foothill streams around the South Bay, where they graze on algal or diatomaceous films (Powell and Hogue 1979). In contrast, shaded, steeper, lower-order streams in higher elevation areas support more vegetation shredders, because most of the plant material in these areas of streams is large and relatively undecayed. Shredders include larval or naiad members of many caddisflies, mayflies, and dipterans (true flies).

Predatory invertebrates, such as larva of species in the Order Odonata (dragonflies and damselflies), larval culicid flies (mosquitos), some larval stoneflies, and adults of certain hemipterans (true bugs) and coleopterans (beetles), occur throughout all stream types. Some predaceous insects are so large and powerful that their prey can include tadpoles or even small fish. Giant water striders (*Gerris reigis*, Hemiptera:Gerridae) are common on many types of surface aquatic habitats across the area from smaller high elevation streams to stock tanks, while toad bugs (*Gelastocoris oculatus*, Hemiptera:Gelastocoridae) hunt for prey along the shores of water bodies. Other impressively large and common aquatic hemipterans include the large water boatman (*Hesperocorixa laevigata*, Hemiptera:Corixidae) and

common water scorpion (*Ranatra brevicollis*, Hemiptera:Nepidae). Aquatic predaceous beetles such as dytiscids and gyrinids are predaceous both as larval and adult forms, and common species or genera in the area include giant green water beetles (*Dytiscus marginicollis*, Coleoptera:Dytiscidae), river beetles (*Agabus* sp., Coleoptera:Dytiscidae), and common whirligig beetles (*Gyrinus* sp., Coleoptera:Gyrinidae).

In the South Bay, studies of freshwater invertebrates have focused primarily on invertebrate assemblages in the middle and upper reaches of streams entering the Bay. In comparison, there are relatively few data on the downstream reaches of these streams, the reaches that are present within the Shoreline Study Area. A 1997 study of stream macroinvertebrates in the Santa Clara Valley identified 261 taxa at 44 sites along seven streams (Carter and Fend 2000). Taxon richness decreased from upstream to downstream sampling locations. Generally, higher-elevation sites supported higher taxon richness and a higher percentage composition of the Orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies), while lower-elevation sites supported a higher percentage composition of taxa contained within the Chironomidae (midges) and Oligochaeta (worms). These results parallel perceived gradients in stream water quality, with mayflies, stoneflies, and caddisflies generally having low tolerance of stream pollutants and midges and oligochaete worms being much more tolerant of low water quality.

In the vernal pool habitats of the Warm Springs Unit of the SFBNWR, studies of invertebrates have focused primarily on the federally endangered vernal pool tadpole shrimp; this species is discussed in detail below under Section 4.3.1).

Upland Invertebrate Communities. As in much of the American West, there has been limited published data providing comprehensive species lists for the upland invertebrate communities of the South Bay. In fact, much like annual plants, insect populations can be extremely ephemeral from year to year, with a given species reaching large densities in some years and appearing completely absent from the fauna in others. The following provides a very general description of the species that would be most likely found in upland habitat, since a more detailed description would go far beyond the scope of this document. When considering ecosystem function, four principal groups bear discussion: soil fauna, responsible for consuming decayed organic matter (detritivores) or those that predate upon soil detritivores; phytophagous invertebrates, which consume tissue from living plants; zoophagous invertebrates, which predate or parasitize other invertebrates or larger animals; and pollinators, responsible for reproduction of many flowering plants. Upland habitat contains an immensely diverse array of terrestrial invertebrates including multiple species in the Hexapoda (insects), Diplopoda (millipedes), Chilopoda (centipedes), Arachnida (arachnoids, including spiders, mites, and ticks), Gastropoda (terrestrial snails and slugs), Malacostraca (terrestrial crustaceans), and Oligochaeta (worms).

Invertebrates that reside primarily in soil or under tree bark on fallen, dead logs comprise an important component of the terrestrial habitat of the South Bay and include a diverse array of species that specialize in feeding on decaying organic material, or that predate on other detritivores in the soil profile. Soil macrofauna carry out extremely important ecosystem functions by facilitating nutrient cycling through their feeding activities and soil perturbation. Some representative examples of soil macrofauna include colonial insects such as ants (Hymenoptera:Formicidae) and termites (Isoptera). The South Bay hosts colonies of invasive Argentine ants (*Iridomyrmex humilis*, Hymenoptera:Formicidae), as well as red

mound ants (*Formica* sp., Hymenoptera:Formicidae). Western subterranean termites (*Reticulitermes hesperus*, Isoptera:Rhinotermitidae) may be the most common termite within the South Bay, and is responsible for structural damage to buildings. Many beetles are also present in the soil, including dung beetles such as the European dung beetle (*Aphodius fimetarius*, Coleoptera:Scarabidae), which is common wherever livestock is kept; and carrion or burying beetles such as *Nicophorus* sp. (Coleoptera: Silphidae), which are important processors of mammalian carcasses. Although not well known as a group due to their tiny size, entognathous (internal mouth-part) insects (orders Protura, Diplura, and Collembola) are extremely numerous in all non-saturated soil samples, and are concomitantly some of the most important detritivores. Springtails (Collembola) are among the best-known entognathous insects, including lawn springtails (*Bourletiella arvalis*, Collembola), which can be found almost anywhere in California, and obese springtails (*Morulina multatuberculata*, Collembola), which prefer hilly, wooded areas. There are also large, common, non-hexapodous invertebrates such as earthworms, millipedes, centipedes and pillbugs.

Phytophagous invertebrates in the Study Area include numerous insect species in the Coleoptera (e.g., weevils, leaf beetles, bark beetles), Homoptera (hoppers, cicadas, aphids, whiteflies and scale insects), Hemiptera (e.g., seed bugs and leaf bugs), Thysanoptera (thrips), larval Lepidoptera (caterpillars), Orthoptera (grasshoppers, crickets, and katydids), Phasmida (walking sticks and leaf insects), Psocoptera (woodlice and booklice), and Neuroptera (lacewings), as well as arachnid mites (Acarina) and terrestrial gastropods (snails and slugs). This terrestrial group is important as a major ecosystem pathway for converting low-protein, high-cellulose plant tissue into high-protein, easily-digestible animal tissue. While these groups can be pests when dealing with gardens, lawns, or crops, they also control and structure plant populations. This group is very speciose, as physical and chemical plant defenses against invertebrate pests are often formidable and require specific adaptations. Many phytophagous insects are restricted to particular plant families, genera, or even species, and other groups are further restricted to certain plant parts, such as the thrips, which feed only within flower blossoms.

Zoophagous invertebrates include both those groups that feed on other invertebrates, as well as those adapted to be parasites of larger animals such as birds and mammals (e.g. ticks, lice, and fleas). Invertebrates that predate upon other invertebrates are important for structuring invertebrate communities and controlling numbers of insect pests. This group includes many species within the Diptera (e.g., asilid and tabanid flies), Neuroptera (e.g. snakeflies, antlions, and dobsonflies), Hymenoptera (parasitic and predatory wasps, ants, and bees), Strepsiptera (twisted wing parasites), Mantodea (mantises), Hemiptera (assassin bugs and toe biters) and Coleoptera (e.g., ladybugs and tiger beetles). Another categorization within the zoophagous invertebrates includes those species that are parasites of birds and mammals, such as biting lice (Mallophaga), which specialize on bird hosts; sucking lice (Anoplura), which typically specialize on mammalian hosts; Siphonaptera (fleas); dipterans such as mosquitos (Diptera:Culicidae) and biting gnats (Diptera:Ceratopoginidae); and Acarina (ticks). These species are important vectors of mammalian and avian diseases.

Those invertebrates that serve as potential pollinators in the upland habitats of the South Bay include insects in the Orders Hymenoptera, Diptera, Lepidoptera and Coleoptera. Not all flower-visiting insects are competent pollinators, as they must sequentially visit flowers of the same species, and have

compatible behavior and morphology with the floral parts so that pollen picked up and deposited on receptive stigmatic surfaces. Bees (Apidae) are hymenopterans specifically adapted to collecting pollen and nectar from plants, and are often, although not always, competent pollinators of the plants that they visit. European honeybees (*Apis mellifera*, Hymenoptera:Apidae) are extremely important naturalized pollinators of many South Bay plants. Native bees include bumblebees (*Bombus* sp., Hymenoptera:Apidae), the short leafcutter bee (*Megachile brevis*, Hymenoptera:Megachilidae), loosely colonial minute sweat bees (*Halictus* and *Lasioglossum* sp., Hymenoptera:Halictidae), and common burrowing bees (*Andrena* sp., Hymenoptera:Andrenidae). Wasps (Vespidae, Sphecidae, Tiphidae) are other hymenopterans that may pollinate plants, but also predate upon or parasitize other insects for their larva. Several flies in the Syrphidae (flower flies) and Bombyliidae (bee flies) are also pollinators, although these are often generally considered less competent at pollen movement than bees. Lepidopteran adults are also often observed visiting flowers, although their morphology is such that they also tend to carry less pollen than bees. Coleopteran pollinators include beetles in the Meloidae (blister beetles) and Cerambycidae (longhorn beetles), including the special status species the Valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*, Coleoptera:Cerambycidae). Flower-visiting beetles consume a large proportion of the pollen produced by the plants they visit, and only incidentally move pollen while foraging.

Invasive Invertebrates of the South Bay. According to Cohen and Carlton (2003), the San Francisco Estuary is the most invaded aquatic ecosystem in North America. This study is the most recent and most inclusive compilation of information on aquatic invasive species in the San Francisco Estuary. Previous lists and/or descriptions of introduced aquatic species include works on fish fauna by Moyle (1976) and McGinnis (1984), freshwater mollusks by Hanna (1966) and Taylor (1981), marine mollusks by Nichols et al. (1986), and introduced marine and estuarine invertebrates by Carlton (Carlton 1975; Carlton 1979a; Carlton 1979b; Carlton et al. 1990). Collectively, these non-native species have significant impacts on the San Francisco Estuary through aggressive predation, highly efficient filter feeding, and competition, which, when magnified by the great abundance of some of these species, has the potential to change (or already has changed) the trophic structure and dynamics of the Bay ecosystem (Josselyn et al. 2004).

Cohen and Carlton (2003) note that at least 212 species, 69% of which are invertebrates, have been introduced to the Bay and Delta since 1850. The most important include a number of clams, many of which were introduced into the Bay via releases of ballast water (Cohen and Carlton 1995), such as the introduced Asian species of *Venerupis* and *Musculista*, and the Atlantic clam *Gemma*. With the exception of the Baltic clam, the numerically dominant mollusks of the South Bay are all non-native species (Nichols and Pamatmat 1988). Collectively, these introduced clam species are capable of filtering the entire volume of the South Bay daily, in addition to having dramatic impacts on the Bay's phytoplankton populations. Cohen and Carlton (2003) suggest that the phytoplankton populations of the northern reaches of the San Francisco Bay may be continuously and permanently controlled by introduced clams.

The Asian clam *Potamocorbula amurensis*, the most abundant clam in the San Francisco Bay, was introduced via ballast water around 1986 (Cohen 1998). Since then, this filter feeder has impacted phytoplankton populations in the North Bay (Alpine and Cloern 1992), preventing summer phytoplankton blooms since its introduction and altering the trophic structure of the North Bay. Although similar large-

scale impacts on the South Bay have not yet been detected, the species is present in the South Bay. This clam was found by a CDFG study to be the most important prey of scoters in Suisun Bay (Harvey et al. 1982). The gem clam (*Gemma gemma*) occurs throughout the South Bay, in both deep subtidal and high intertidal habitats. It occurs in lower-salinity salt ponds as well. This clam is eaten by a variety of shorebirds (Recher 1966) and waterfowl (Painter 1966), and thus benefits some native wildlife species. The Atlantic ribbed marsh mussel (*Arcuatula demissa*) was introduced in the late 1800s, and is now common throughout much of the Bay. Although it is apparently “a major food source” for the clapper rail, rails have been known to drown after getting their beaks or toes caught in the open valves of the mussel (Takekawa 1993). The soft-shell clam (*Mya arenaria*) was introduced for commercial purposes, and maintained an important fishery in the Bay in the late 1800s and early 1900s (Skinner 1962). Although it is still present in the Bay, most individuals are small (Thompson and Shouse 2004). It is an important prey item for bat rays, flounder, and in the Suisun Bay, canvasbacks (Harvey et al. 1982). Thompson (1999) found that it disappeared rapidly from areas where it recruits, suggesting that it is preyed upon heavily by these fish, and possibly by birds and other invertebrates.

A carnivorous opisthobranch, *Philine auriformis*, invaded the South Bay in 1982, and has been noted in abundance in bottom trawls by the Marine Sciences Institute (Thompson and Shouse 2004). This species, which has been found most frequently in deeper water, preys on bivalves. The polychaete worm *Streblospio benedicti* was first detected in the Bay in 1932. This species readily colonizes the Bay in both deep and shallow intertidal habitats, and is consistently one of the dominant species on South Bay mudflats.

The dominant crustaceans of the South Bay are all introduced as well. The tube-dwelling amphipod *Ampelisca abdita* was first detected in the Bay in the 1950s. Since then, it has increased in abundance, and can achieve very dense beds at a variety of depths. This species was a dominant species on Palo Alto mudflats until the 1990s, when abundance declined (though it has remained common) (Thompson and Shouse 2004). The other dominant crustaceans in the South Bay include several burrowing amphipods, including *Grandidierella japonica* and several non-native *Corophium* species. Both of these genera tolerate poor water quality, and readily colonize available habitat throughout the South Bay. These crustaceans are important prey species for shorebirds on intertidal mudflats.

The European green crab (*Carcinus maenas*) became established in the San Francisco Bay in 1989-1990. This opportunistic omnivore eats a variety of plant and animal matter, including bivalves and shore crabs, and has the potential to impact native species considerably (Josselyn et al. 2004). After its invasion of Bodega Bay in 1993, a 90-95% decline in the abundance of native bivalves and grapsid shore crabs was observed (Grosholz et al. 2000).

Two non-native species could physically impact South Bay marshes, levees, streambanks, and other structures. The Australian-New Zealand boring isopod (*Sphaeroma quoyanum*) burrows into mud banks and levees throughout the Bay, potentially weakening these features and making them prone to erosion (Talley et al. 2001). Another burrowing species that may cause the same problem is the Chinese mitten crab (*Eriocheir sinensis*), which has been known to accelerate bank erosions in Germany. First detected in the Bay in 1992, the mitten crab has undergone rapid population increases throughout the Bay and its

tributaries. This catadromous species migrates upstream (in virtually all of the Bay's tributaries) year-round, peaking in spring. Downstream migration to saltwater (approximately 25 ppt) breeding areas occurs primarily August-January, with a peak in September-October (Veldhuizen and Stanish 1999). The Chinese mitten crab is common in the South Bay. Halat (1996) has reported that the burrows of this crab reach densities of 30 burrows/m² along San Francisquito Creek. Halat did not report any bank erosion even at this density of mitten crab borrows but suggested that if bank erosion does occur it is likely to occur along steep clay banks in tidally influenced alluvial controlled reaches of the Bay. Thompson and Shouse (2004) noted abundant Chinese mitten crab burrows in a salt marsh bank in Palo Alto, possibly due to its proximity to San Francisquito Creek, and speculated that the erosion of the salt marsh bank observed since the mitten crab's invasion in the early 1990s may have been caused by the crab's burrowing. Surveys by the Marine Science Institute recorded burrow densities as high as 6.2/m² in December 1995 and 8.9/m² in March 2000 along Alviso Slough. These densities are three to 4.5 times greater than the next highest density for the South Bay.

Mosquitoes. There is an extensive body of literature on mosquitoes associated with tidal and seasonal wetlands of the South Bay region, as summarized by Bohart and Washino (1978), Durso (1996), and Maffei (2000d; 2000e; 2000f; 2000g; 2000h). More than 20 species occur in the San Francisco Bay area, but five of these, the summer salt marsh mosquito (*Aedes dorsalis*), winter salt marsh mosquito (*Aedes squamiger*), Washino's mosquito (*Aedes washinoi*), western encephalitis mosquito (*Culex tarsalis*), and winter marsh mosquito (*Culiseta inornata*), are routinely controlled by the mosquito and vector control agencies within each of the counties of South San Francisco Bay. Within the Shoreline Study Area, the Alameda County Mosquito Abatement District and the Santa Clara Vector Control District are responsible for managing the populations of mosquitoes for their respective communities.

The Goals Project's Baylands Ecosystem Species and Community Profiles (Maffei 2000d; 2000e; 2000f; 2000g; 2000h) included a detailed discussion of the ecology of mosquitoes in the South Bay, including preferred habitats, salinity tolerances, reproductive rates, flight characteristics, adult hosts and vector/nuisance potential. Adult females feed on blood; the hosts vary depending on the species, but include mammals, birds, reptiles, and amphibians. Adult males feed on plant juices, while larvae generally feed on particulate matter, unicellular algae, and other microorganisms. Larvae serve as prey for a variety of aquatic organisms, shorebirds, and waterfowl, while birds such as the swallow and other insects feed on adult mosquitoes. Larval survivorship is typically low, with most losses attributable to predation. The rate of larval development is often a function of water temperature and food availability.

The summer salt marsh mosquito is widespread throughout most of the United States and southern Canada, and is found in Europe and Asia as well (Carpenter and LaCasse 1955; Darsie and Ward 1981). In California, it inhabits coastal salt marshes and brackish marshes of the Sacramento/San Joaquin River Delta (Bohart and Washino 1978). In the San Francisco Bay area, this species occurs primarily in temporarily flooded tidal marsh pannes, heavily vegetated ditches, and brackish seasonal wetlands, while adults occur in open habitats such as grasslands, salt marsh, and woodland edges (Maffei 2000d). The summer salt marsh mosquito lays its eggs on mud at the edges of tidal pools or brackish seasonal wetlands, with larvae often occupying the same pools occupied by the tidal pool brine fly (*Ephydra millbrae*) and reticulate water boatman (Maffei 2000d). Eggs may hatch in the spring, but they can

remain viable for years, and subsequent hatching can occur when the larval habitat is reflooded. Although survivorship may be highest in water having a salinity near seawater (Washino and Jensen 1990), larvae have successfully completed development at the Great Salt Lake in water with salinities as high as 120 ppt (Rees and Nielsen 1947). Up to 12 broods and eight generations were found to occur during a single breeding season in Marin County (Telford 1958). Adults are highly mobile, aggressive, day-biting mosquitoes that may be able to disperse more than 30 miles (Rees and Nielsen 1947).

The winter salt marsh mosquito occurs along the Pacific Coast from Sonoma County south to Baja California, including much of the immediate area around Southern and Northern portions of San Francisco Bay (Maffei 2000h). Tidal and diked pickleweed marshes with salt marsh pools diluted by rains provide the preferred habitat of this species. This species has not been found in freshwater marshes, instead occurring in brackish and salt marshes having salt concentrations from 1.2 to 35 ppt, with optimal conditions for larval development at salinities of five to 15 ppt. Egg laying occurs in spring on plants and on mud close to the edges of marsh pools. The eggs lie dormant until fall rains inundate them, although hatching as early as late September has been noted due to water diversion into a marsh. Some eggs do not hatch until later re-floodings. Most adults emerge from salt marsh pools in late February and March and disperse widely into surrounding areas, sometimes dispersing as far as 15 miles or more from larval areas. Feeding occurs from March through June, with biting occurring during daytime and early dusk.

Washino's mosquito occurs from Oregon south to Santa Barbara, California, including the entire San Francisco Bay area (Maffei 2000e). In the Bay area, shallow pools and fresh to slightly brackish sites in uplands near salt marshes or in riparian areas, often dominated by willow, cottonwood, or blackberry, provide this species' preferred habitat. Females deposit eggs in mud along the receding water line of larval habitat. The eggs hatch when these pools are reflooded the following winter. Adults emerge from the larval depressions in late winter and early spring, and are present into June. Females are day-biting mosquitoes, and may travel up to 1.5 miles from their larval habitat along artificial canals (Maffei 2000e).

The western encephalitis mosquito is widespread in a variety of habitats and locations in western North America, with larvae occurring in most freshwater habitats (Maffei 2000f). Typical larval habitat includes poorly drained fields and pastures, rice fields, marshes, ponds, and seeps, although most artificial waterbodies in urban areas provide potential habitat for this species as well. The species has been found in salt marsh pools with salt concentrations up to ten ppt (Telford 1958). Adults may be present year-round but enter facultative diapause in winter. Females lay eggs in groups directly into the water. Adult females usually feed at night. This species seems to be able to disperse readily with wind, and dispersal distances of 20-25 miles are suspected for some Sacramento Valley populations (Bailey et al. 1965). The western encephalitis mosquito is the main vector of western equine encephalitis and St. Louis encephalitis in most of the western United States (Maffei 2000f), and is a vector of avian malaria.

The winter marsh mosquito occurs in a wide range of habitats throughout much of western North America. Larval habitat includes a variety of pools, ponds, marshes, and other water bodies, in salinities ranging from eight to 26 ppt (Maffei 2000g; Telford 1958). Adults are present from fall through spring, entering facultative diapause in summer. Females lay groups of eggs directly on the water. San Francisco Bay populations tend to remain within two miles of their larval source, although they may

disperse up to 14 miles (Clarke 1943). Larvae of the summer salt marsh mosquito, winter salt marsh mosquito, and winter marsh mosquito are often found in the same locations (Maffei 2000h). Mosquito species occurring in the major habitats in the Shoreline Study Area are listed in Table 4 below.

Table 4 – Mosquito Species Found in Marsh Habitats in the Shoreline Study Area.

Habitat	Mosquito Species
Open salt pond with vigorous wave action	none
Fully tidal salt marsh: Higher ground with pools or borrow channels that do not flush	<i>Aedes squamiger</i> (winter), <i>Aedes melanimon</i> (fall), <i>Aedes dorsalis</i> (summer), <i>Aedes taeniorhynchus</i> (summer), <i>Culiseta inornata</i> (winter)
Muted tidal salt marsh: Pools and channels that do not flush vigorously	<i>Aedes squamiger</i> (winter), <i>Aedes melanimon</i> (fall), <i>Aedes dorsalis</i> (summer), <i>Aedes taeniorhynchus</i> (summer), <i>Culiseta inornata</i> (winter)
Seasonal wetland: Brackish to nearly freshwater pools with vegetated margins	<i>Aedes squamiger</i> (winter), <i>Aedes melanimon</i> (fall), <i>Aedes dorsalis</i> (summer), <i>Aedes taeniorhynchus</i> (summer), <i>Aedes washinoi</i> (winter fresh water), <i>Culex tarsalis</i> (spring, summer), <i>Culex erythrothorax</i> (summer in tules), <i>Culex pipiens</i> (foul fresh water), <i>Culiseta incidens</i> (spring, fall fresh water), <i>Culiseta inornata</i> (winter)
Vernal pools, upland freshwater marsh	<i>Aedes washinoi</i> (winter), <i>Culex tarsalis</i> (spring, summer), <i>Culex erythrothorax</i> (summer in tules), <i>Culex pipiens</i> (foul fresh water), <i>Culiseta incidens</i> (spring, fall fresh water), <i>Culiseta inornata</i> (winter)

Marshes that lack vigorous tidal flow can provide suitable mosquito breeding habitat. Salt marshes at the southern end of the San Francisco Bay produce a single seasonal brood of the winter salt marsh mosquito and multiple broods of the summer salt marsh mosquito each season. Because both of these mosquito species can fly considerable distances and are aggressive biters, control of mosquitos at the source (i.e., in salt marshes) is necessary to reduce the inconvenience to humans in the South Bay.

Detailed records are maintained by the local mosquito and vector control districts concerning major mosquito breeding areas, population densities, and control techniques and materials. In Santa Clara County, areas with known or potential mosquito problems include Coyote Reach 1A, New Chicago Marsh, Sunnyvale Baylands Park, the Moffett Field Flood Control Basin, Mountain View Demonstration Marsh, the Palo Alto Flood Basin (Palo Alto Baylands Park), the Zanker Landfill Marsh, Dow-Corning Marsh, Alviso Marshes, ITT Marsh (near the Palo Alto Water Quality Control Plant), the Palo Alto Municipal Airport, and the Palo Alto Municipal Golf Course (Strickman 2005). In the Alameda County portion of the Study Area, south of the San Mateo Bridge, sites that can produce large numbers of mosquitoes if not treated include the Perry Duck Club, Alameda Creek Marshes, Union City Marshes, Coyote Hills Marshes, Mayhew's Landing, and the upper ends of major sloughs (Mowry, Newark, Plummer, Albrae, and Mud Sloughs). Fully tidal marshes such as Hook Island (Palo Alto), Triangle Marsh (Coyote Creek), and Greco Island, do not produce significant numbers of mosquitoes.

Mosquito control techniques employed by these agencies emphasize minimization and disruption of suitable habitat, and control of larvae through chemical and biological means, as opposed to spraying of adults. Control techniques most often include source reduction, source prevention, larviciding, use of

mosquito fish (*Gambusia affinis*) as larval predators, and monitoring of mosquito populations and vector-borne diseases (Alameda County Mosquito Abatement District 1999). Larvicides employed by the San Mateo County Mosquito Abatement District include Golden Bear 11 11 (a short-lived petroleum distillate that is applied to the surface of the water and causes mosquito larvae to drown), methoprene (a juvenile growth hormone that specifically targets mosquito larvae and prevents their maturation), *Bacillus thuringiensis israelis* (a bacteria that is toxic to mosquito larvae), and *Bacillus sphaericus* spores and toxin (for *Culex* species) (http://www.smcmad.org/preventative_approach.htm).

In salt marshes, attempts to control mosquito populations by ditching have resulted in marsh degradation. Ditching is not necessary to reduce mosquito populations in tidal marshes. Rather, functional tidal marshes do not provide high-quality habitat for the most troublesome mosquito species in the Bay area, and maintenance and restoration of natural tidal flushing in these marshes is effective at limiting mosquito populations while sustaining the natural hydrology of the marsh (San Francisco Bay Joint Venture 2004).

Mosquitos serve as vectors for several diseases that pose health concerns for humans and domestic animals. The western encephalitis mosquito is a vector of avian malaria and the main vector of western equine encephalitis and St. Louis encephalitis in the western United States (Maffei 2000f). Anopheles mosquitos carry the organism that causes malaria. The West Nile virus is a mosquito-borne disease that has been found in parts of Asia, Eastern Europe, Africa and the Middle East. First detected in the U.S. in 1999 in New York City, West Nile virus has since spread through most of the U.S. West Nile Virus is typically spread from an infected mosquito, usually in the genus *Culex*, to a bird that then disperses or migrates, spreading the virus after being bitten by other mosquitos. Most people and domestic animals that become infected with the virus have few or no symptoms, but in rare cases they can become seriously ill. In 2006, West Nile virus was detected in 54 of 58 California counties, with 276 human infections from 30 counties in California (http://westnile.ca.gov/latest_activity.htm). In 2006, 58 infections of horses from 23 counties in California were reported, along with 1446 dead birds that tested positive for the virus.

4.3.2 Fishes

Fishes play very important ecological roles in the South Bay system. Information on South Bay fish communities is somewhat limited, likely due to the lack of a commercial fin-fishing industry in this part of the Bay. However, a dataset from the CDFG and several other studies provide information on fishes of the South Bay's tidal habitats, while several studies have identified the fish present in South Bay salt ponds (Anderson 1970; Carpelan 1957; Lonzarich 1989; Takekawa et al. 2005) and freshwater streams (summarized in Buchan et al. 2002). Information on key species is also available in the Goals Project's Baylands Ecosystem Species and Community Profiles (Goals Project 2000).

Fish Communities of Tidal Habitats. More than 100 fish species have been recorded in the tidal waters of the South Bay (Laine, pers. comm.). The California Department of Fish and Game has conducted a fish survey within the San Francisco Bay since 1980, with monthly surveys in deeper subtidal areas and some beach seine sampling in shallow water habitats (CDFG data in Life Science 2004). These surveys

include data from three open-water stations (Stations 102, 101, and 140) located near the San Mateo and Dumbarton Bridges, and two beach seine stations (171 and 172) that are also located in the South Bay. Three sampling methods were used in the open-water stations: the otter trawl (which was towed on the bottom for five minutes against the current, then retrieved), midwater trawl (which was towed with the current for 12 minutes then retrieved obliquely), and plankton net (which was towed on the bottom for five minutes then retrieved obliquely).

A total of 65 fish species was captured at Stations 102, 101, and 140 during CDFG's surveys between 1980 and 2002, with 51 species captured by the otter trawl, 48 species by the midwater trawl, and 27 by the plankton net. Table 5 summarizes the most abundant fish species captured during these surveys. Numerically, the dominant fish were the northern anchovy (*Engraulis mordax*), shiner surfperch (*Cymatogaster aggregata*), longfin smelt (*Spirinchus thaleichthys*), white croaker (*Genyonemus lineatus*), Pacific staghorn sculpin, bay goby (*Lepidogobius lepidus*), plainfin midshipman (*Porichthys notatus*), English sole (*Parophrys vetulus*), cheekspot goby (*Ilypnus gilberti*), and Pacific herring (*Clupea pallasii*). The dominant fish captured at the beach seine stations were topsmelt (37.3%), arrow goby (*Clevelandia ios*, 22.6%), yellowfin goby (16.9%), jacksmelt (*Atherinopsis californiensis*, 16.2%), and Pacific staghorn sculpin (3.3%), with 22 other species representing <2% of the catch at Station 171, and topsmelt (54.4%), jacksmelt (23.4%), Pacific herring (9.7%), Pacific staghorn sculpin (3.0%), and northern anchovy (2.0%), with 28 other species representing <2% of the catch at Station 172.

Kinnetics (1987) collected fish from two locations in Coyote Creek and one location in Guadalupe Slough between 1982 and 1985. The dominant species collected from these sloughs included the staghorn sculpin, northern anchovy, starry flounder (*Platichthys stellatus*), shiner perch, yellowfin goby, threadfin shad (*Dorosma petenense*), and longfin smelt. Fish sampling in the nearby open waters of the Bay revealed species composition similar to that in the sloughs, with white croaker and striped bass (*Morone saxatilis*) also occurring as dominants. Sampling fish in lower San Francisquito Creek and the Palo Alto Water Quality Control Plant outfall channel, Cressey (1997) recorded the northern anchovy, topsmelt, yellowfin goby, staghorn sculpin, and threespine stickleback (*Gasterosteus aculeatus*).

Surveys of South Bay tidal sloughs by the USGS (Takekawa et al. 2005) from March 2004 to June 2005 recorded a total of 16 fish species in Alviso Slough, Coyote Creek, and Stevens Creek. Northern anchovies and topsmelt were by far the most abundant species caught; the American shad (*Alosa sapidissima*), threadfin shad, longjaw mudsucker, longfin smelt, common carp (*Cyprinus carpio*), starry flounder, rainwater killifish, bat ray, leopard shark (*Triakis semifasciata*), Sacramento sucker (*Catostomus occidentalis occidentalis*), striped bass, staghorn sculpin, shiner surfperch, and yellowfin goby were also recorded.

Many of the fish recorded in the South Bay, including the bat ray, leopard shark, northern anchovy, gobies, and many others, occur in tidal channels within marshes, in sloughs, and/or on mudflats at high tide when they are inundated. Thus, these tidal channels and mudflats are productive foraging habitats for estuarine fish in this system (Harvey 1988).

The spatial and temporal distribution of different estuarine fish in the South Bay, vary widely among species, as does the degree to which different species use the Bay for breeding and foraging. The South Bay is particularly important to the leopard shark. Popping (live birth) in the San Francisco Bay occurs almost exclusively in the South Bay (CDFG Bay Trawl data cited in McGowan (2000a)). This species appears to be most abundant in the areas on either side of the Dumbarton Bridge, where it forages in shallow mud and sand flats (Compagno 1984). Leopard sharks occur in the Bay year-round, although individuals may move in and out of the Bay (McGowan 2000b). The Bay is also important for northern anchovies, which spawn in the South Bay, including areas south of the Dumbarton Bridge (McGowan 1986). Spawning occurs in marsh channels; larvae forage over shallow flats after hatching (McGowan 2000b). Adult anchovies generally leave the Bay for the open ocean in fall, but some late-spawned juveniles remain in the Bay throughout the winter. Jacksmelt likely spawn in the South Bay as well. Here, spawning occurs from October to early August (Wang 1986), when adults move inshore from marine habitats and lay eggs on aquatic vegetation and other substrates. Apparently preferring more saline waters, the jacksmelt is most common in the Central and South Bays during years of high freshwater flows from the Delta (CDFG 1987 in Saiki [2000b]).

Table 5 – Summary of the most abundant fish species captured during California Department of Fish and Game South Bay fishery surveys, 1980-2002. Data are from Stations 101, 102, and 140 between the San Mateo and Dumbarton Bridges.

Species	Station 101			Station 102			Station 140		
	Otter Trawl	Midwater Trawl	Plankton Net	Otter Trawl	Midwater Trawl	Plankton Net	Otter Trawl	Midwater Trawl	Plankton Net
Northern Anchovy ¹	34.8	93.5	85.5	24.6	92.8	82.2	7.7	87.7	36.7
Shiner Perch	19.2			17.1			34.7	2.3	
Longfin Smelt	13.9								
White Croaker	9.8			3.5			4.4	3.2	
Pacific Staghorn Sculpin	4.5						7.0		
Bay Goby	4.3			19.1			8.3		
Plainfin Midshipman	3.1						7.9		
English Sole				12.0			7.4		
Cheekspot Goby				5.7					
Speckled Sanddab				4.0			2.1		
Pacific Herring			5.7	3.5		10.3			2.3
California Tonguefish							3.9		
White Seaperch							3.0		
Brown Smoothhound							2.4		
Topsmelt					2.2				
Jacksmelt					2.0				
Walleye Surfperch								2.1	

Arrow/Cheekspot Goby			2.8						21.1
Yellowfin Goby			2.3						
Goby Type II			2.2			2.0			3.8
Unidentified Fish									34.1
Total Species Richness	42	36	22	46	42	24	48	42	27
Other Species (Percent)	10.4	6.5	1.5	10.5	3.0	5.5	11.2	4.7	2.0

[†] Only species that make up at least 2.0% of the catch for a given sampling method at a given station are included. Data are the percentage of the total number of fish caught that were composed of each species.

Adult topsmelt enter shallow sloughs and mudflats to spawn in late spring and summer, which has been observed in the South Bay near the Dumbarton Bridge (Wang 1986). Eggs are laid on submerged vegetation. Locally this species is most abundant in the South Bay; where mudflats and sloughs are used for spawning and feeding, and as nursery areas for juveniles (Saiki 2000c). The Pacific staghorn sculpin is most abundant in central and north San Francisco Bay, but in some years it occurs commonly in the South Bay as well (CDFG 1987 in Tasto (2000b)). This sculpin spawns from November to March in shallow subtidal to intertidal water, and the young gradually shift their foraging areas from shallow intertidal habitats to deeper subtidal habitats as they mature (Tasto 2000b). The arrow goby occurs on shallow intertidal flats and in salt-marsh channels throughout much of the South Bay, where it is often commensal with burrowing invertebrates (Hieb 2000a). This species breeds primarily in spring and early summer, with peak larval occurrence from April through July. The bay goby occurs in somewhat deeper-water habitats than the arrow goby, and is also a common breeding species in the South Bay (Hieb 2000b). The longjaw mudsucker resides on mudflats and in tidal channels and sloughs. Marshes with complex channels provide the highest-quality habitat, although this species also breeds in lower-salinity salt ponds (Hieb 2000c). The longjaw mudsucker spawns from November through June in the South Bay, constructing burrows for breeding.

Other species forage in the South Bay but are not known to breed here. Pacific Herring are present in the North Bay from November through March, when spawning occurs; larvae and juveniles occur more widely, during which time they occur in the South Bay (though abundance decreases southward). Most individuals depart the Bay by August (Tasto 2000a). Longfin smelt spawn in fresh water in the upper end of Suisun Bay and in the Delta, occurring in the South Bay year-round as pre-spawning adults and yearling juveniles (Wernette 2000). Striped bass were introduced into the San Francisco Estuary in 1879, and are now the most important sport fish in the San Francisco Estuary, bringing in approximately \$45 million per year into the local economies of the Estuary (Sommer 2000). Adults congregate in the San Pablo and Suisun Bays in fall and move into the Delta to spawn primarily in the Sacramento/San Joaquin Rivers in May and June. Striped bass in the South Bay are likely subadult fish foraging widely in the Bay, as this species is not known to breed in the South Bay. The California halibut (*Paralichthys californicus*) forages to some extent in the South Bay, but is not known to breed anywhere inside San Francisco Bay (Saiki 2000a). Juvenile starry flounders (*Platichthys stellatus*) occur fairly commonly in

South Bay sloughs, tidal marsh channels, and mudflats, although this species is not known to breed in the Bay (Kline 2000).

Adult steelhead (*Oncorhynchus mykiss*; Central California coast DPS) migrate through the Shoreline Study area into freshwater streams within the South Bay typically from December through April. Outmigration of smolts mainly occurs from February through June (Roessler et al. 2001, SCVWD unpublished data). Chinook salmon (*Oncorhynchus tshawytscha*), Central Valley Fall-Run ESU, also migrate through the Study area during adult upstream migration from August through December, and during the downstream migration of juveniles typically from February through June (Roessler et al. 2001, SCVWD unpublished data). Relatively few data are available regarding use of South Bay marshes by salmonids, due to the difficulty of sampling small fish in this habitat. Steelhead were not captured by the CDFG during its South Bay surveys, and Chinook salmon were captured only in very low numbers. These species are discussed in detail in the Special-Status Wildlife Species section below (Section 3.7).

The diets of South Bay fish vary widely (Goals Project 2000; Harvey et al. 1977). Herring, anchovies, perch, and a variety of other fish and shrimp species provide prey for striped bass. The American shad feeds on copepods, larval fish, and *Corophium*. Northern anchovies are filter feeders that capture zooplankton and phytoplankton. Gobies prey on small fish and crustaceans. Jacksmelt eat a variety of copepods, insects, and polychaetes. Longfin smelt feed on zooplankton, shrimp, and copepods. Chinook salmon (*Oncorhynchus tshawytscha*) prey on insects, shrimp, amphipods, and isopods. The Pacific sardine (*Sardinops sagax*) is a filter and particulate feeder. The bat ray feeds on benthic mollusks, polychaete worms, and crustaceans. Leopard sharks eat a variety of crabs, shrimp, and small fish.

The history of the fisheries in the San Francisco Bay area, based on commercial catch data, was well described by Skinner (1962), but information specific to the South Bay in that text is very limited. According to Thomas Laine (pers. comm.), saltwater fish have declined in abundance in the far South Bay, with an apparent decline being particularly noticeable in the Alviso area since the 1970s. Although no commercial fishery for fin-fishes has existed in the Alviso area, this area was important for recreational fishing, particularly for sturgeon and striped bass, when the boat ramp at the Alviso marina was operational, and fishing derbies for sturgeon in the 1970s attracted as many as 700 entrants (Laine, pers. comm.). Large sturgeon and striped bass are still caught in the South Bay, but public boating access is limited to boat launches at the SFBNWR headquarters entrance in Newark and in the Redwood City area (except for the few boats currently moored along Alviso Slough).

Salt Pond Fish Communities. Fish community composition and abundance within the salt ponds of the South Bay are primarily a function of salinity, with more diverse communities and greater abundance in lower-salinity ponds, and generally no fish surviving salinities greater than 100 ppt. Carpelan (1957) found that in the Alviso salt ponds he studied, the primary fish species were topsmelt and threespine stickleback. Stickleback, primarily a freshwater species, occurred in low-salinity ponds, where they were often noted in clear water above macrophytic green algae. Topsmelt were the most abundant fish species, occurring in ponds with salinities up to 55 ppt. These fish feed in the salt ponds primarily on copepods. The longjaw mudsucker and the Pacific staghorn sculpin also occurred in the lower salinity Alviso ponds, but in lower abundance.

Lonzarich and Smith (1997) more recently studied fish assemblages in Alviso ponds A9 through A12, finding topsmelt, threespine stickleback, and longjaw mudsucker to be common in low- to mid-salinity ponds (35-90 ppt). Adult topsmelt occurred in ponds with salinities up to 90 ppt, and juvenile topsmelt occurred in ponds up to 75 ppt. Rainwater killifish (*Lucania parva*) and yellowfin gobies were also resident in most ponds studied. Nine additional fish species recorded in salt ponds by Lonzarich and Smith (1997), including staghorn sculpin, leopard shark (*Triakis semifasciata*), and northern anchovy, were apparently seasonal transients from adjacent Bay waters.

Surveys by USGS (Takekawa et al. 2005) recorded 14 fish species in Alviso salt ponds between March 2004 and June 2005; these results are similar to those of Lonzarich and Smith (1997), with longjaw mudsucker, rainwater killifish, topsmelt, and yellowfin goby being the most abundant fish, although very few sticklebacks were caught by USGS. Other species recorded in the Alviso salt ponds by USGS included northern anchovy, bay pipefish, staghorn sculpin, chameleon goby (*Tridentiger trigonocephalus*), leopard shark, shiner surfperch, striped bass, starry flounder, and bat ray.

Freshwater Stream Fish Communities. Fishes in the freshwater streams entering the Bay in the Shoreline Study Area consist of a moderately diverse assemblage of native species augmented by a number of non-natives. Coyote Creek has been the best studied of the creeks entering the Study Area in terms of its fish communities; such studies were summarized in Appendix C of Buchan et al. (2002). Native species recorded along lower Coyote Creek between 1858 and 2000, and thought to be extant as of 2000, include the splittail (*Pogonichthys macrolepidotus*), Pacific lamprey (*Lampetra tridentata*), steelhead/rainbow trout, California roach (*Lavinia symmetricus*), hitch (*Lavinia exilicauda*), Sacramento blackfish (*Orthodon microlepidotus*), Sacramento pikeminnow (*Ptychocheilus grandis*), Sacramento sucker, threespine stickleback, prickly sculpin, riffle sculpin (*Cottus gulosus*), and staghorn sculpin (Buchan et al. 2002, Buchan and Randall 2003). Other natives, such as the thicktail chub (*Gila crassicauda*), Sacramento perch (*Archoplites interruptus*), coho salmon (*Oncorhynchus kisutch*), speckled dace (*Rhinichthys osculus*) were recorded historically in lower Coyote Creek but may have been extirpated.

Anadromous fish, such as the Central California Coast steelhead and Chinook salmon use the reaches of freshwater streams in the Study Area primarily during movements between upstream spawning areas and estuarine/oceanic habitats. Coho salmon (*Oncorhynchus kisutch*) formerly spawned in the Coyote Creek watershed, but was apparently extirpated by the 1970s.

A variety of non-native fish introduced either unintentionally or intentionally for angling or mosquito control, occurs in South Bay freshwater streams. These include the mosquitofish (*Gambusia affinis*), channel catfish (*Ictalurus punctatus*), brown bullhead (*Ictalurus nebulosus*), yellow bullhead (*Ameiurus natakis*), black bullhead (*Ameiurus melas*), white crappie (*Pomoxis annularis*), black crappie (*Pomoxis nigromaculatus*), red shiner (*Notropis lutrensis*), inland silverside (*Menidia beryllina*), carp (*Cyprinus carpio*), goldfish (*Carassius auratus*), fathead minnow (*Pimephales promelas*), redear sunfish (*Lepomis microlophus*), bluegill (*Lepomis macrochirus*), green sunfish (*Lepomis cyanellus*), largemouth bass (*Micropterus salmoides*), golden shiner (*Notemigonus crysoleucas*), and others (Buchan et al. 2002, Buchan and Randall 2003). Many of these non-natives are widespread in streams throughout central

California, and are fairly tolerant of marginal water quality and a variety of stream conditions. The number of non-native fish species recorded along lower Coyote Creek increased from zero during the period 1858-1940 to 21 during the period 1987-2000 (Buchan et al. 2002).

4.3.3 Reptiles and Amphibians

Relatively few species of reptiles and amphibians occur in the Shoreline Study Area, and consequently, there has been little study of these taxa within the Study Area. The western fence lizard (*Sceloporus occidentalis*), a ubiquitous lizard in California, occurs in a variety of habitats in the Study Area. Other reptile species that occur within the Study Area include garter snakes (*Thamnophis couchi*, *T. elegans*, and *T. sirtalis*), gopher snakes (*Pituophis melanoleucus*), and southern alligator lizards (*Elgaria multicaranata*), all of which occur along edges of well-vegetated levees, in riparian habitats, and in grassland and ruderal habitats.

A small, isolated population of western pond turtles (*Clemmys marmorata*) occurs in brackish habitats near the Sunnyvale WPCP and Moffett Field, and this species is also present in small numbers along the lower reaches of Coyote Creek and the Guadalupe River (see Special-Status Wildlife Species in Section 3.7). Small numbers of a several species of non-native turtles, most likely pets that have been released, are present in South Bay streams as well.

Due to the paucity of freshwater habitats within the immediate Study Area, amphibian use of the Study Area is even more limited. Where fresh water occurs along the inland margins of the Study Area, the Pacific treefrog (*Hyla regilla*), western toad (*Bufo boreas*), and non-native bullfrog (*Rana catesbeiana*) are present. California slender salamanders (*Batrachoseps attenuatus*) and arboreal salamanders (*Aneides lugubris*) occur in moist riparian areas along the margins of the Study Area, but are much more abundant in higher-elevation, more wooded, less urbanized sites outside the Study Area. California tiger salamanders (*Ambystoma californiense*) occur in vernal pool habitats in the Warm Springs area, primarily on SFBNWR lands.

4.3.4 Mammals

Relatively few species of mammals occur in the Shoreline Study Area owing to the intense disturbance and habitat conversion that has occurred within the area. Within the Study Area, most research attention on mammals has focused on the ecology of special-status salt marsh associated species (i.e., the salt marsh harvest mouse and salt marsh wandering shrew, along with other small mammals using salt marshes), the use of South Bay waters and tidal habitats by the Pacific harbor seal, and the presence and impacts of non-native mammals. Upland habitats within the Study Area are primarily ruderal, although some non-native grassland habitat and the riparian corridor of Coyote Creek do support a variety of small mammal species.

Salt marsh harvest mice and salt marsh wandering shrews occur in the Study Area primarily in pickleweed-dominated salt marshes. Harbor seals, the only marine mammals that regularly occur in the

South Bay, forage in Bay waters and sloughs and breed and loaf on the edges of tidal marshes and mudflats. Because these three species are discussed in detail in the Special-Status Wildlife Species section (Section 3.7), they are not discussed further in this section.

Trapping studies for the salt marsh harvest mouse in the South Bay have revealed much about the status of other small mammals in marsh habitats of the region. House mice (*Mus musculus*) and California voles are common in diked and tidal salt marshes, particularly in the pickleweed-dominated high marsh and the peripheral halophyte zone, where the western harvest mouse (*Reithrodontomys megalotis*) also occurs in the high marsh. Deer mice (*Peromyscus maniculatus*), shrews, and both black rats (*Rattus rattus*) and Norway rats (*Rattus norvegicus*) are also recorded in these marshes during salt marsh harvest mouse trapping studies. Table 6 below lists the results of a small sample of such studies to indicate the relative abundance (relative to trapping effort and among species) of these species in South Bay marshes (Environmental Science Associates 1991; H. T. Harvey & Associates 1988; 1989; 1990; 1991; Harvey and Stanley Associates 1985; 1986; Muench 1985; Shellhammer et al. 1988; Wondolleck et al. 1972).

Aside from the introduced house mouse, which occurs commonly in a variety of habitats in the South Bay, the most abundant mammal trapped during the studies listed in Table 6 was the California vole. This species is a common inhabitant of grasslands, ruderal habitats, and wetlands around the South Bay, and is a keystone species in grasslands due to its importance as a prey species to mammals and raptors (Pearson 1985) and the significant effect this species may have on vegetation during populations peaks (Lidicker 1989; Lidicker 2000). Studies of populations in upland areas have demonstrated dramatic fluctuations in abundance, and when it is particularly abundant, the California vole may have adverse effects on other small mammals. For example, western harvest mice are impacted strongly, presumably via competitive interactions, during vole outbreaks, and it is possible that high densities of voles may have the same negative impacts on salt marsh harvest mice, as has been suggested by Geissel et al. (1988).

Several species of bats, such as the Mexican free-tailed bat (*Tadarida brasiliensis*), forage over the salt ponds, marshes, and grasslands of the South Bay. Native mammals such as the California vole, western harvest mouse, deer mouse, Botta's pocket gopher (*Thomomys bottae*), California ground squirrel, black-tailed jack rabbit, Audubon's cottontail, brush rabbit, striped skunk (*Mephitis mephitis*), and long-tailed weasel (*Mustela frenata*) occur on salt pond levees, at the margins of marshes, and in upland ruderal and grassland habitats around the periphery of the Study Area.

Several non-native mammal species occur in the South Bay, including the red fox (*Vulpes vulpes regalis*), Norway rat, black rat, feral cat (*Felis felis*), and Virginia opossum (*Didelphis virginiana*). These species have the potential to impact populations of California clapper rails and other native species in the South Bay considerably. The red fox was first reported in the South San Francisco Bay area in 1986 (Foerster and Takekawa 1991), and it has since increased and expanded to become established throughout the Bay area. It dens in a variety of habitats, including salt pond levees (Foerster and Takekawa 1991).

Table 6 – Relative abundance of small mammals captured during selected salt marsh harvest mouse trapping studies in the South Bay.

Site and Habitat	Year(s)	Trap Nights	Species*							Reference
			Salt Marsh Harvest Mouse	Western Harvest Mouse	House Mouse	Deer Mouse	California Vole	Shrew spp.	Black / Norway Rat	
1990 Bay Road, East Palo Alto (tidal salt marsh)	1990-91	1000	20		3	1	3		3	Environmental Science Associates 1991
Dumbarton Marsh (tidal salt marsh)	1990-91	1000	18		8	1	16	1		Environmental Science Associates 1991
Palo Alto Baylands (salt marsh)	1972	2058	196		74		39	3		Wondolleck et al. 1972
Western Alameda and Northeastern Santa Clara Counties (diked marsh)	1983-86	12,800	140	45	717	54	478	10	3	Shellhammer et al. 1988
Western Alameda County (tidal salt marsh)	1983-86	1200	13	7	72		129	2		Shellhammer et al. 1988
Lower Calabazas Creek at Hwy. 237, Alviso (fresh/brackish tidal marsh)	1988	1000		3	46					H. T. Harvey & Associates 1988
Coyote Creek Flood Control Project (ruderal/alkali habitat)	1990	1000	7	4 (harvest mouse sp.)	21	2	1			H. T. Harvey & Associates 1990c
Mayhews Landing (mixed grassland, diked marsh, fresh/brackish marsh)	1988-89	3120	36		101					H. T. Harvey & Associates 1989
Warm Spring International Industrial Park (diked pickleweed marsh)	1985	900	1		36	7				Harvey and Stanley Associates 1985
Warm Springs II/Fremont Airport (diked pickleweed/grassland)	1985	2400	27		≤ 154					Harvey and Stanley Associates 1986
Triangle Marsh (tidal salt marsh) and New Chicago Marsh (diked salt marsh)	1985	776	1	1	161	1	6	1		Muench 1985
Triangle Marsh (tidal salt marsh)	1990	500	10		8	3	18			H. T. Harvey & Associates 1991c

Site and Habitat	Year(s)	Trap Nights	Species*							Reference
			Salt Marsh Harvest Mouse	Western Harvest Mouse	House Mouse	Deer Mouse	California Vole	Shrew spp.	Black / Norway Rat	
Calaveras Point Marsh (tidal salt marsh)	1990	400	22							H. T. Harvey & Associates 1991c
Warm Springs Marsh (tidal brackish marsh)	1990	500			35	31	57			H. T. Harvey & Associates 1991c
Coyote Creek Flood Control Project (ruderal/alkali habitat)	2001	800		3	22					H. T. Harvey & Associates 2001
Stevens Creek Marsh (tidal salt marsh)	2005	400	2	1	40	4				H. T. Harvey & Associates 2005
Calaveras Point Marsh (tidal salt marsh)	2006	2000	15		4	5				H. T. Harvey & Associates 2007
Triangle Marsh (tidal salt marsh)	2006	2000	28		37	6	53			H. T. Harvey & Associates 2007
Warm Springs Marsh (tidal brackish marsh)	2006	2000	10		18					H. T. Harvey & Associates 2007

* In these studies, species other than salt marsh harvest mice were not uniquely marked for identification, and hence the numbers listed for species other than the salt marsh harvest mouse include an unknown number of recaptures. However, the house mouse and California vole were still found to be the most abundance species in many marshes.

Clapper rail predation by both red foxes and feral cats has been directly documented in the South Bay by the tracking of radio-marked rails that were depredated in 1991 and 1992 (Albertson 1995). In addition, the remains of clapper rails were found at a fox den in a tidal marsh on the SFBNWR (Harding et al. 1998), and at the entrance to a den in the outboard levee along salt pond A9 (Steve Rottenborn, pers. obs.). Norway rats are thought to be one of the main predators of California clapper rail eggs (Foerster et al. 1990; Harvey 1988), and raccoons have also been known to prey on California clapper rail eggs (Foerster et al. 1990). In addition to impacts to clapper rails, red fox predation on nests of the federally threatened western snowy plover has been recorded, and fox predation has resulted in the abandonment of important colonies of Caspian terns (at Mowry and Bair Island) and herons (at Bair Island) in the South Bay in 1991 (Strong 2004a).

The feral cat is fairly common in upland habitats around the South Bay (Foerster and Takekawa 1991; Takekawa 1993), whereas the Norway rat and roof rat occur in most habitat types in the Study Area. Both rats are known nest predators of California clapper rails, and up to one-third of clapper rail eggs in the South Bay may be depredated by Norway rats (BDOC Unpublished; Josselyn et al. 2004). Rats have depredated California Gull nests in the South Bay as well (Jones 1986).

In 1991, the San Francisco Bay NWR implemented a predator management plan directed at the removal of red foxes, raccoons (*Procyon lotor*), striped skunks, and feral cats to protect the federally listed California clapper rail and western snowy plover (Harding et al. 1998). From spring 1991 to fall 1996, the average number of individuals removed from NWR lands per year included 90 red foxes, 27 feral cats, 26 striped skunks, and two raccoons. In addition, 38 non-native opossums and 25 native gray foxes (*Urocyon cinereoargenteus*) were captured and released. The number of red foxes trapped was consistent from 1991 to 1996, but trapping rates declined because more traps were used in successive years. Successful trapping required 46 traps/fox in 1991-1992 and 83 traps/fox in 1995-1996, suggesting that the trapping program was successful in reducing fox populations. More than half of the cats and skunks trapped were in the Warm Springs/Fremont area. In 2003, the CDFG implemented a predator-control program at the Eden Landing Ecological Reserve to reduce predation on listed species (John Krause, pers. comm.).

4.3.5 Birds

The birds of the South Bay have been studied more than any other wildlife group. This focused attention results from the high diversity of birds in the region, the presence of several San Francisco Bay-area endemics and state and federally listed species, the plasticity demonstrated by a number of species in adapting to the anthropogenic changes (including salt pond development and urbanization) that have occurred in the South Bay, and the intensity of interest in the birdlife of the region by professional and amateur ornithologists. The birds of the Bay and associated salt ponds and marshes represent the most significant contribution of the South Bay to the avifauna of the Pacific Flyway, and the following discussion focuses primarily on birds associated with these areas. In addition, riparian habitats in the Study Area, though limited in extent, provide important foraging habitat for migrants and wintering birds and valuable breeding habitat for a few riparian-associated species.

Overview of Baylands Bird Communities. The San Francisco Bay area is extremely important to breeding birds and, particularly, to migratory waterbirds in the Pacific Flyway. The Bay provides important foraging and roosting habitat for more than one million waterbirds each year, supporting large proportions of the populations of some shorebird and duck species (Accurso 1992; Harrington and Perry 1995; Page et al. 1999; Stenzel et al. 1989; Stenzel and Page 1988; Takekawa et al. 2001). With its extensive mudflats, remnant salt marsh, and salt ponds, the South Bay in particular supports very high diversity and abundance of waterbirds (Harvey et al. 1992; Takekawa et al. 2000; Warnock 2004b). More than 250 bird species occur in the greater South Bay area with some regularity, and many of these are common inhabitants of the Shoreline Study Area and its immediate vicinity. More than 75 species of waterbirds use the salt ponds, tidal marshes, mudflats, subtidal habitats, and surrounding managed marshes, water treatment plants, and managed ponds regularly, with more than 50 species more occurring rarely and/or in low numbers. Species richness in the South Bay system is generally highest in fall and lowest in summer and winter, while waterbird abundance is highest in spring and winter (Strong 2003; Takekawa et al. 2001; Takekawa et al. 2004). In Bay-wide surveys, Bollman et al. (1970) found waterbird abundance to be lowest in summer, increasing rapidly in early September and peaking in December.

The high waterbird diversity in the South Bay is a function of the diversity of wetland and aquatic habitats in the region, while high bird abundance is a function of the high productivity of the South Bay estuary and, secondarily, of alternative habitats such as salt ponds. Despite the extensive loss and degradation of the South Bay's tidal marsh, and the invasion of the South Bay benthic invertebrate community by non-native species, this system is still extremely productive. The remnant tidal marshes not only provide habitat for marsh obligates such as the California clapper rail, they also play important roles as sources of nutrients and carbon for the aquatic system, resulting in high abundance of invertebrates on the mudflats and shallow subtidal areas (Warwick and Price 1975), and ultimately high fish populations. These invertebrates and fish in turn serve as prey to the myriad shorebirds, waterfowl, herons, egrets, gulls, terns, grebes, and other waterbirds that use the South Bay.

Salt ponds and other alternative habitats (such as artificial ponds and lakes, water treatment plant settling and oxidation ponds, muted and managed marshes, and managed ponds) also provide important habitat for waterbirds in the South Bay (Hanson and Kopec 1994; Harvey et al. 1992; Stralberg et al. 2003; Takekawa et al. 2000; Takekawa et al. 2001; Warnock 2004b). Though salt ponds are more or less closed systems, providing little input of carbon or nutrients to the estuary itself, the concentration of superabundant invertebrate prey in salt ponds, provision of alternate foraging habitat during high tide, provision of roosting sites, and concentration of fish in lower-salinity ponds results in suitable foraging conditions for a variety of waterbirds. For some species, such as the Wilson's phalarope, red-necked phalarope, black-necked stilt, American avocet, western snowy plover, Bonaparte's gull, American white pelican, and breeding gulls and terns, these ponds provide higher-quality nesting and/or foraging habitat than the existing tidal marshes or intertidal habitats. A number of other species use salt ponds primarily when their preferred intertidal habitats are inundated, or when high densities may cause some birds to forage in less optimal areas (Warnock and Takekawa 1995). For such species, the question of whether salt ponds and other alternate habitats are required for foraging, or whether they are required primarily for high-tide roost sites, varies among species, and possibly among seasons (i.e., being more important for

foraging when densities are high). Alternate habitats such as salt ponds and levees are required for high-tide roosting sites, refugia from strong winds, and foraging sites during prolonged winter storms, when winds, rain, and high water may limit foraging efficiency and limit the availability of intertidal foraging areas (Davidson and Evans 1986; Evans 1976; Pienkowski 1981).

Although birds may be very abundant in salt ponds during high tide, most bird activity is concentrated in small areas within the larger salt pond complexes. For example, Stralberg et al. (2003) reported that 90% of the small shorebirds and dabbling ducks in their South Bay study area were recorded in six of 22 ponds under study, while 90% of the larger shorebirds were recorded in ten of 22 ponds. This concentration is a result of the dispersion of suitable foraging habitat and prey availability, which may be concentrated in relatively few ponds having suitable water depths and salinities. It has been reported that salt ponds close to the edge of the Bay have greater bird use than those farther from the Bay, and that many shorebirds use mudflats and salt ponds in close proximity to one another (Warnock and Takekawa 1996), thus reducing commuting distances between low-tide intertidal foraging habitat and high-tide refugia within the ponds for birds that use both habitats. Studies of color-marked or radio-tagged shorebirds in the South Bay indicate that many individuals have high site fidelity and small home ranges, often using the same roosting and foraging sites consistently (Kelly and Cogswell 1979; Warnock and Takekawa 1996). Wintering western sandpipers in the South Bay were found to have a mean home range size of 22 km², and the mean distance between feeding and roosting areas was 2.2 ± 0.1 km, although some birds moved around quite a bit, particularly within pond complexes. Warnock and Takekawa (1996) found less movement from one side of the Bay to the other. While the ponds supporting the greatest use do tend to be closer to the Bay (Takekawa et al. 2005), and many birds may repeatedly use the same small areas, waterbirds in some areas are known to repeatedly travel longer distances (e.g., thousands of shorebirds regularly commuting more than four miles between intertidal foraging areas and high-tide roosting areas near the NWR headquarters in Newark; (Morris 2004)). The sudden appearance of large numbers of shorebirds when salt ponds were drained during ISP implementation (Krause, pers. comm.; H. T. Harvey & Associates Unpublished), or of large numbers of piscivores at prey fish “blooms” (Steve Rottenborn, pers. obs.), is also indicative of these birds’ potential for significant local movement to exploit favorable foraging conditions.

A few studies have compared the use of salt ponds with the use of other available habitats (e.g., tidal marsh, mudflats, and subtidal areas) in the South Bay. Within salt ponds and nearby mudflats near Coyote Hills, Swarth et al. (1982) found higher bird species richness in low-salinity ponds than in higher-salinity ponds or mudflats, although relatively few species used the salt ponds at low tide. In contrast, Takekawa et al. (2001) found species richness and diversity in the North Bay to be higher in natural baylands (i.e., tidal marsh and mudflats) than in salt ponds during all seasons, while overall bird density was higher in salt ponds than in baylands in winter and spring (and overall was twice as high in salt ponds than in baylands). During Bay-wide surveys, Bollman et al. (1970) found that salt ponds supported densities of waterbirds (57-73 birds/acre) two to three times higher than mudflats (29-30 birds/acre) and open water (15-18 birds/acre). At any given time, the proportion of a salt pond or mudflat in use by foraging birds may be relatively small, as birds often concentrate in areas providing the most suitable conditions, complicating the comparison of densities among these habitat types. Studies of shorebird use

of different South Bay habitats during high tide, coordinated by SFBBO, are summarized under Shorebirds, below.

Stralberg et al. (2003), comparing use of salt ponds with a limited sampling of tidal marshes (though not including tidal mudflats in the comparison), found that salt ponds had significantly higher species richness than tidal marshes, with a mean of 47 species/pond. However, salt ponds supported high densities of relatively few species, with only occasional use by many of the species contributing to the high species richness in the ponds; in contrast, tidal marsh was used at lower densities by many species. Warnock et al. (2002) confirmed this finding, reporting that ten species (out of 75 recorded) composed >85% of all birds recorded in 22 salt ponds in the South Bay. Thus, tidal marsh provides habitat for more species more consistently; salt pond use by most species is more limited or irregular, but may be very important (to large numbers of individuals of at least some species) at times. Within salt ponds, species richness decreases with salinity, though many species use a wide range of salinities. Of the 50 most common species in salt ponds, the core salinity range for 34 included low-salinity (20-60 ppt) ponds, with 18 found only in this range; mid-salinity (60-120 ppt) ponds were within the core salinity range for 31 species. No species were restricted only to high-salinity ponds (Stralberg et al. 2003).

Stralberg et al. (2003) found waterbird species richness and diversity in tidal marshes negatively associated with the proportion of salt ponds in the surrounding landscape and positively associated with the proportion of surrounding mudflat and marsh. Within marshes, waterbird diversity was higher in marshes with more large channels, and the densities of ducks, larids, and shorebirds increased with increasing amounts of open water within the marsh; waders and other piscivores increased with larger channels in marsh.

The use of individual salt ponds, and foraging locations within those salt ponds, by foraging waterbirds is determined primarily by prey availability, which is mainly a function of salinity and water depth. Warnock et al. (2002) reported bird diversity in South Bay salt ponds to be highest at mid-salinity ponds (± 126 ppt), while bird density on salt ponds peaks at higher salinities (± 140 ppt). Due to variations in bill and leg length, foraging behavior (i.e., swimming, wading, or diving), and prey preferences, different waterbird species are able to, or prefer to, forage in water of different depths (Isola et al. 2000). Thus, ponds with more topographic heterogeneity, such as islands and uneven bottoms, are important in providing habitat for a greater diversity of foraging guilds by providing a range of foraging depths (Anderson 1970; Takekawa et al. 2004; Velasquez 1993; Warnock 2004b).

The most recent and comprehensive dataset on bird use of the South Bay salt ponds themselves has been compiled by USGS, which has been conducting monthly bird surveys at 53 ponds in the South Bay Salt Ponds complexes (USGS, unpubl. preliminary data). Surveys have been conducted since January 2002 in some of the Alviso Complex ponds (and at all Alviso ponds since January 2003). In addition, the Cargill-managed ponds in the Mowry, Newark, and Coyote Hills pond complexes have been surveyed by SFBBO (using the same methods used by USGS) since 2005. Because management of the salt ponds included in this study may have differed from prior management in anticipation of the purchase of these ponds (and/or their mineral rights) from Cargill (Takekawa, pers. comm.) and because these surveys overlap the implementation of ISP management in some ponds, these data cannot be clearly related to pre-ISP or to

ISP conditions, making it difficult to ascribe mechanisms to the patterns observed. Nevertheless, this dataset is useful in characterizing the general temporal and spatial distributions of birds in the Study Area salt ponds at the present time.

From October 2002 to June 2005, the surveys by USGS had recorded 75 species of waterbirds in the Alviso Complex. Excluding Ponds A19-A23 (since these ponds were not surveyed as many times as the remaining ponds), the number of species/pond ranged from a low of 30 species in the mostly dry Pond A6 to 59 in Pond A9. Ponds A1, A5, A7, A10, and AB2 supported 50-56 species each, while ponds with the lowest species richness included A6, A12, A13, A15, and A17. Although it is likely not possible to determine the mechanisms responsible for these patterns, since ISP conditions were implemented during the study period in some ponds, those ponds having high species richness tended to be large ponds with high topographic variability that included both shallow and deep water, thus providing foraging habitat for a number of foraging guilds. Low-diversity ponds tended to be deep-water ponds with little topographic heterogeneity or ponds that contained little water during the year. Ponds supporting high waterbird abundance during the period October 2002 to June 2005 in the Alviso Complex were Ponds A5 (due largely to high western sandpiper abundance, and high abundance of other species), A6 (due to the large California gull colony in this pond), and A9 (due to high abundance of many species, particularly ducks); Ponds A12, A13, A15, A16, A17, and AB1 supported the lowest bird abundance.

Continued surveys by USGS from July 2005 to August 2006 recorded more than 1.75 million observations of waterbirds representing 67 species in the Alviso Complex salt ponds (Takekawa et al. 2006). These ponds supported higher abundance of certain groups than the Ravenswood and Eden Landing complexes surveyed simultaneously, hosting 96% of the gulls, 84% of dabbling ducks, 83% of diving ducks, 74% of piscivores, and 71% of herons recorded among the three pond complexes. The complex consisting of A1, A2W, A2E, AB1, AB2, A3N, and A3W supported 55% of the diving ducks in the Alviso complex. Ponds A5, A6, and A8 collectively supported 80% of the small shorebirds and 42% of the medium shorebirds in the Alviso complex. The high-salinity ponds, such as pond A13, supported the highest numbers of phalaropes and eared grebes.

The majority of the information on birds of the salt ponds within the Study Area is based on data collected prior to ISP implementation since the ISP has been only recently implemented in some salt ponds (and the effects of this implementation on wildlife use have not yet been fully identified) and has not yet been implemented in other ponds. Ongoing studies by USGS, SFBBO, and others will help to refine the response of wildlife to implementation of the ISP. Already, monitoring data indicates an overall reduction in numbers of salt pond-specialist birds (e.g., eared grebes and phalaropes) as fewer ponds are managed for high-salinity conditions, an increase (at least locally, at the pond or pond complex level) in abundance of small shorebirds in ponds managed for shallow depths, and an increase in abundance of dabbling ducks in ponds that are converted from high-salinity to low-salinity ponds.

Birds in the South Bay overlap considerably in habitat preference and resource use, but general groups of species can be distinguished based on their physical adaptations, habitat associations, foraging behavior, dietary requirements and prey, the ways in which they use salt ponds as habitats (e.g., for nesting, foraging, or roosting), and their temporal occurrence in the Study Area. For the purposes of describing

the existing conditions of the bird community in the South Bay, six general groups of species have been identified: shorebirds; waterfowl (ducks and geese); large waders (herons, egrets, and ibis) and other piscivores (fish-eating grebes, cormorants, and pelicans); larids (gulls and terns); other waterbirds (eared grebes, coots, and rails); and landbirds (including raptors and passerines). Each of these groups is discussed in detail below.

Shorebirds. Perhaps no other group of birds using the South San Francisco Bay has been better studied than shorebirds, which include plovers, sandpipers, stilts, avocets, and phalaropes, and perhaps no other group relies more heavily on the South Bay. Comprehensive shorebird surveys of the Pacific Coast of the U.S., summarized by Page et al. (1999), have documented that the San Francisco Bay supports 41-97% (mean 67%) of estimated totals for key species for the entire West Coast in fall, 38-90% (mean 55.7%) in winter, and 24-86% (mean 52.3%) in spring. No other site on the West Coast of the U.S. supports a mean greater than 8% in any season. For 11 shorebird species, the San Francisco Bay supports >50% of the individuals recorded in all U.S. Pacific Coast wetlands in at least one season. The percentage of the total West Coast population of individual shorebird species that occurs in San Francisco Bay in fall, winter, and spring, respectively, include numbers as high as 62%, 59%, and 56% for black-bellied plovers (*Pluvialis squatarola*); 59%, 68%, and 54% for western sandpipers; 67%, 39%, and 73% for least sandpipers; 78%, 90%, and 58% for black-necked stilts; 97%, 88%, and 86% for American avocets; and 69%, 59%, and 57% for willets (*Catoptrophorus semipalmatus*). The San Francisco Bay supports an average of more than 40% of the West Coast populations over these three seasons for semipalmated plover (*Charadrius semipalmatus*), red knot (*Calidris canutus*), dowitchers (*Limnodromus* spp.), long-billed curlews (*Numenius americanus*), and marbled godwits (*Limosa fedoa*) as well. The San Francisco Bay likely supports more than one million shorebirds in spring and hundreds of thousands in the fall and winter (Stenzel et al. 1989). As a result of these numbers, the San Francisco/San Pablo Bay area has been designated as a site of hemispheric importance by the Western Hemisphere Shorebird Reserve Network (Harrington and Perry 1995), and the Don Edwards San Francisco Bay NWR has been designated a Globally Important Bird Area by the American Bird Conservancy (2004).

The South Bay is the most important part of the larger San Francisco Bay from the perspective of use by breeding, migrant, and wintering shorebirds. Of 838,000 shorebirds counted during a Bay-wide survey 16-18 April 1988, 70% were recorded south of the San Mateo Bridge, with the highest concentration at low tide occurring on the broad intertidal flats on the east side of the Bay between the San Mateo and Dumbarton bridges (Stenzel and Page 1988). Mudflats and salt ponds on the east side of the Bay between these two bridges supported approximately 305,000 shorebirds during this survey, compared to 62,000 on the west side of the Bay between the bridges and 224,000 south of the Dumbarton Bridge. Of nearly 379,000 shorebirds counted during another Bay-wide survey 9-12 September 1988, 75% were recorded south of the San Mateo Bridge; within this area, 128,000 shorebirds were south of the Dumbarton Bridge, compared to 25,000 on the west shore and 77,000 on the east shore between the Dumbarton and San Mateo Bridges (Stenzel et al. 1989). The wintering shorebird population in the South Bay was estimated by Harvey et al. (1988) to exceed 200,000.

Most of the shorebirds that use the South Bay do so only for foraging and roosting but do not breed here. Only four shorebird species breed within the baylands habitats of the South Bay, while 20 species

regularly use the South Bay for foraging and roosting as nonbreeders, and 19 additional shorebird species occur only as rare visitors to the area. Most individuals of most shorebird species in the South Bay forage primarily on intertidal mudflats when these flats are available at low tide. These individuals then seek high-tide refugia in salt ponds, on levees, in other alternative habitats in the area (e.g., water treatment plants, managed ponds, and muted or managed marshes), and to a limited extent in tidal marsh; here, most individuals of the larger shorebird species simply roost until the tide recedes again, while some individuals of the smaller shorebird species forage in their high-tide habitats. A few shorebird species remain in these alternative habitats throughout the tidal cycle, using salt ponds, water treatment plants, and managed ponds and marshes for foraging regardless of tide height.

Shorebird abundance in the South Bay is highest in spring and winter. For most species, the spring migration is rapid and compressed to a relatively brief period from early April to mid-May (Recher 1966; Stenzel and Page 1989), resulting in large numbers of individuals using the South Bay simultaneously. In contrast, the fall migration is more protracted for most species, as different sexes and age classes migrate in fall at different times. Shorebird abundance is lowest during summer, when only breeding individuals of four species and low numbers of non-breeders of other species are present. However, the summer period for shorebirds is very short in the South Bay – late spring migrants may move through the area as late as late May or early June, and the first fall migrants (usually Wilson’s phalaropes) begin to arrive in mid-June, with the first southbound arrivals of a number of other species appearing by late June and early July. Fall migration then continues through October.

Breeding. Prior to conversion of tidal marshes to salt ponds in the San Francisco Bay area in the mid 1800s, only one shorebird species, the killdeer likely bred in the South Bay. This species breeds on open ground in a variety of habitats, and open sand, gravel, or soil suitable for breeding was likely present historically. However, the creation of salt ponds in the South Bay has enhanced breeding habitat for several species. The western snowy plover, which nests on salt flats and islands within salt ponds, likely did not breed in the South Bay prior to late 1800s; although salinas were present in the tidal salt marsh, they were not extensive and may not have been large enough to support breeding by this species (Goals Project 1999). This species was first recorded breeding in salt ponds in 1918 (Harvey et al. 1992), and today, snowy plovers nest on levees, islands, and salt flats throughout the South Bay salt ponds, occurring in highest concentrations in the Eden Landing area. This species is discussed in greater detail below in the Special-Status Wildlife Species section (Section 3.7).

The American avocet and black-necked stilt also did not breed in the San Francisco Bay area prior to the creation of salt ponds. These species were first recorded breeding in Bay-area salt ponds in 1926 and 1927, respectively (Gill 1977; Harvey et al. 1992). Since then, their populations have increased considerably, with avocet population estimates of 1800 pairs in 1971 (Gill 1977) and 540 pairs in 1981 (Rigney and Rigney 1981), and stilt population estimates of 400-500 pairs in 1971 (Gill 1977) and 600-650 pairs in 1981 (Rigney and Rigney 1981). More recently, a breeding-season survey of the South Bay by Rintoul and others (2003) counted 1184 black-necked stilts and 2765 American avocets, with the number of breeding pairs estimated at 135-590 for stilts and 440-1380 for avocets. No other coastal site along the Pacific Coast supports such high abundance of these two species (Rintoul et al. 2003).

Both stilts and avocets nest at scattered locations throughout the Shoreline Study Area, although Rintoul et al. (2003) noted particularly large concentrations of both species in New Chicago Marsh in Alviso, with another concentration of avocets in the Warm Springs area along the upper edges of the salt ponds and marshes (Figure 2). Rintoul et al. (2003) noted an increase in the importance of the Eden Landing area for nesting stilts and avocets since 1981 (Rigney and Rigney 1981). It is not clear whether their surveys covered the San Jose/Santa Clara WPCP, where on 10 May 1997, more than 30 stilt nests were found scattered over the sludge ponds during an informal survey (Steve Rottenborn, pers. obs.).

Rintoul et al. (2003) found 21% of 137 black-necked stilt nests in marshes and 69% around salt ponds; of 409 American avocet nests, 3% were in marshes and 93% were around salt ponds. Stilts used salt ponds and marshes in proportion to availability, while avocets favored salt ponds. Within marshes, stilts tended to use more heavily vegetated areas than avocets. Both species used similar habitats for brooding young (mostly salt ponds, with lesser numbers in marshes). Less than 20% of nests found were on levees; most were on islands, as reported by others (Gill 1973; Harvey et al. 1988; Rigney and Rigney 1981; Robinson et al. 1997; Robinson et al. 1999; Swarth et al. 1982). Both species commonly nest among nesting Forster's terns on islands.

Feeding. As noted previously, the South Bay is the single most important area on the west coast, south of Alaska, for use by migrant and wintering shorebirds. Surveys have documented more than 590,000 shorebirds present simultaneously 16-18 April 1988 (Stenzel and Page 1988) and 230,000 present 9-12 September 1988 (Stenzel et al. 1989) in the South Bay. Because these were only snap-shot surveys, and thus capture only a fraction of the shorebirds that use the South Bay as migratory stopover or staging areas, the actual number of birds that use the South Bay for foraging during migration is much higher. The San Francisco Bay is the northernmost location used by large numbers of shorebirds in winter on the West Coast (Warnock 2004a), and wintering shorebird numbers in the South Bay were estimated by Harvey et al. (1988) to exceed 200,000.

Shorebirds tend to forage in habitats, at times, under conditions, and on prey that provide high foraging efficiency while balancing predation risk and other adverse factors (Goss-Custard 1970; Goss-Custard 1979; Goss-Custard et al. 1977; Van de Kam et al. 2004). Shorebirds tend to concentrate foraging activity where suitable prey is most dense (Skagen and Oman 1996) and/or where such prey is most available (i.e., where the birds can reach and obtain food), although they may alter their behavior (e.g., foraging duration or foraging locations) based on competition from other shorebirds or energetic needs. For example, western sandpipers in the South Bay make more use of salt ponds during spring than during other seasons (Warnock and Takekawa 1996), possibly because high spring shorebird densities force some birds to spread out from preferred intertidal mudflats and forage more heavily in less optimal habitats. In winter, shorebirds may spend more time foraging and less time roosting due to decreased daylength, more rapid energy loss due to cool temperatures, and adverse effects of low temperature on food availability and foraging efficiency (Goss-Custard et al. 1977; Heppleston 1971; Kelly and Cogswell 1979; Van de Kam et al. 2004).

Most shorebird species in the South Bay are mudflat specialists, foraging primarily on intertidal mudflats when these flats are available at low tide (Anderson 1970; Kelly and Cogswell 1979; Recher 1966;

Stralberg et al. 2003; Swarth et al. 1982; Warnock et al. 2002; Warnock et al. 1995). These birds move to mudflats as they uncover on an ebbing tide, often concentrating at the edge of the receding tideline. Near the waterline, worms, crustaceans, and bivalves occur close to the surface, whereas these prey species recede deeper into the mud as the water level drops. Near the waterline, microhabitat use often varies among species based on bill and leg length; Semipalmated and black-bellied plovers feed on recently exposed mud, small sandpipers such as western and least sandpipers forage on recently uncovered mud and shallow water, mid-sized birds such as dunlin, red knots, long-billed dowitchers, and short-billed dowitchers forage in slightly deeper water, and larger shorebirds such as willets, long-billed curlews, and marbled godwits probe in deeper water.

Some authors have reported that the greatest concentrations of shorebirds occur at the receding tideline (Recher and Recher 1969; Stenzel and Page 1988; Storer 1951). Gerstenberg (1979) reported that shorebirds forage along the tideline until it reaches its ebb, then spread out over the tidal flats (especially when bird abundance is high), although he also noted that shorebirds may concentrate along the waterline on both the receding and incoming tide. All of these scenarios have been observed in the South Bay, where shorebirds may be observed foraging along the receding and incoming waterline, and often spread out over the flats as well (Steve Rottenborn, pers. obs.). It is likely that shorebirds use more of the tidal flats when densities are higher, as competition for space and food resources requires the birds to spread out over the flats more.

After the mudflat specialists have finished foraging on the mudflats, they may roost temporarily on the upper mudflats before leaving as the tide rises, or fly directly to alternate sites to roost or, to varying degrees, forage during high tide. Although sites such as water treatment plants, managed ponds (e.g., the Coyote Creek Reach 1A pond), managed/muted tidal marshes, and wet fields are used (heavily at times) by mudflat specialists during high tide, most shorebirds move to the salt ponds. Surveys of South Bay high-tide roosting and foraging sites, coordinated by SFBBO between October 1992 and May 1993, documented 51% of shorebirds using salt ponds at high tide, with 10% on levees around and within salt ponds and other habitats, 10% in tidal marsh, 12% in diked marsh, and up to 4% in inactive salt ponds, uplands, freshwater ponds (including sewage treatment ponds), tidal islands, and salt pannes (Hanson and Kopec 1994).

The use of salt ponds for foraging by mudflat specialists varies considerably among species, and for some species, it varies among individuals, seasons, and possibly age classes. Of the mudflat specialist species, most of the individuals observed in salt ponds at high tide are roosting rather than foraging. For example, over all surveys and all shorebird species recorded during SFBBO's 1992-1993 study, roosting composed 68% of activity at these high-tide areas, while foraging composed 26% of shorebird activity (Hanson and Kopec 1994). The percentage of birds in a given location that were foraging at high tide varied considerably among surveys; for example, <1% of more than 24,400 shorebirds in Pond R1 on 22 March 1993 were foraging, whereas 70% of the 6200+ birds (of similar species composition) in the same pond on 3 May 1993 were foraging at high tide. At times, nearly all birds in a given location were observed foraging at high tide, with foraging activity being particularly high in spring.

Long-billed curlews, marbled godwits, and black-bellied plovers roost in salt ponds but do not use them heavily for foraging (Warnock et al. 2002). Black-bellied plovers, willets, and dowitchers make somewhat greater use of salt ponds for foraging, but still do not forage in salt ponds to a great extent. Most western sandpipers and dunlin use salt ponds primarily for roosting, but forage on moist mud and in shallow water to a greater extent. A greater proportion of least sandpipers seems to use salt ponds for foraging than is observed in other mudflat specialists (Steve Rottenborn, pers. obs.).

Telemetry studies by Warnock and Takekawa (1995; 1996) determined that western sandpipers made greater use of salt pond levees and shallows for foraging during spring, when densities in the South Bay were higher, than during winter. These results suggest that birds depositing fat prior to spring migration may need to spend more time foraging (and thus forage in salt ponds during high tide), and that at higher densities (such as occur during spring migration), more birds are relegated to less preferred habitats, such as salt ponds. Some individuals of other mudflat specialists, particularly least sandpipers, dunlin, and semipalmated plovers, may also take advantage of suitable foraging conditions within salt ponds and remain in these ponds throughout the tidal cycle; even within salt ponds, these birds forage primarily at low tide, with most individuals roosting at high tide (Hanson and Kopec 1994; Warnock et al. 2002).

The mild microclimate of the South Bay may help to explain its high bird use during winter (Warnock and Takekawa 1996). Nevertheless, alternate foraging sites may be particularly important for mudflat specialists during the wet season. High winter tides, combined with sustained strong winds and/or flooding, may reduce the extent to which intertidal mudflats are uncovered, temporarily limiting the availability of these preferred foraging habitats (Storer 1951). Flooding may also wash silt onto mudflats, reducing prey availability or foraging efficiency (Gerstenberg 1979; Warnock and Takekawa 1996). Studies have demonstrated that dunlin in coastal areas may move inland to forage after heavy rains (Warnock et al. 1995).

Several species of shorebirds make little or no use of intertidal mudflats, instead preferring the “alternate” habitats for foraging regardless of tide height (Harvey et al. 1988; Stenzel and Page 1988; Storer 1951; Swarth et al. 1982; Warnock et al. 2002). American avocets forage in shallow pools and wet mud on mudflats, and occasionally in deeper water near the tideline (Hamilton 1975; Storer 1951; Warnock et al. 2002), and snowy plovers may use mudflats for foraging as well, but these species are most abundant in the South Bay in salt ponds. Black-necked stilts and Wilson’s and red-necked phalaropes also occur in the South Bay primarily in salt ponds, rarely foraging in tidal habitats. Greater yellowlegs and lesser yellowlegs (*Tringa flavipes*) forage in a variety of nontidal habitats in the South Bay, including salt ponds, and occur less frequently on tidal mudflats. While these seven pond specialists may occur by the hundreds or thousands in alternate habitats other than salt ponds, the salt ponds support the vast majority of the South Bay’s populations of these species.

Within the salt ponds, water depth and salinity influence the distribution of foraging shorebirds. The abundant invertebrates of the mid- and high-salinity ponds (60-200 ppt), namely brine shrimp, brine flies, and reticulate water boatmen, are important food sources for shorebirds (Larsson 2000; Maffei 2000b; Stralberg et al. 2003; Warnock et al. 2002), but their availability to shorebirds is limited by water depth. Most shorebirds forage in water less than ten to 15 centimeters deep, with depths below four centimeters

being preferred by smaller species such as the western sandpiper, least sandpiper, and dunlin (Isola et al. 2000; Safran et al. 1997). Thus, only the moist soils along the edges of salt ponds, and moist soil or very shallow water within the ponds, provide suitable foraging habitat for these wading species.

The extent of shorebird foraging habitat present within the salt ponds varies considerably among ponds and seasons, but at any given time a relatively small proportion of the salt pond complexes provides suitable conditions (e.g., moist soil or shallow water <ten centimeters deep) for foraging by most shorebirds. Deeper ponds without shallowly sloping sides provide foraging habitat only in a very narrow zone along their immediate periphery. For example, a 12 in-wide strip of moist-soil and shallow-water foraging habitat around the edge of pond A2W (which represent the ponds that lack shallowly sloping sides and are usually flooded) would represent only $\pm 0.1\%$ of the area of this pond.

Calculating the area of suitable foraging habitat for shorebirds over an entire pond complex and across multiple seasons is problematic. Water depth in seasonal ponds may vary considerably among years, seasons, and even months or weeks depending on precipitation levels and temperature. Even in ponds where water levels are managed more actively, the lack of data on microtopography of the pond bottoms and the vagaries of management make it difficult to predict the extent of areas providing water <ten centimeters deep, and floating mats of algae in late summer and fall may provide foraging habitat for birds in ponds >ten centimeters deep. Furthermore, extensive dry flats with thick salt crusts provide only marginal foraging habitat for shorebirds, as prey densities may be low away from the moist-soil and ponded areas. Rough estimates suggest that at any one time, less than 15% of the total salt pond area provides foraging habitat for most shorebirds under ISP management during winter and early spring (when ponds contain the most water), and less than 25% of the salt pond area provides suitable foraging habitat during late summer and fall (when ponds are driest).

In contrast, phalaropes, and American avocets to a lesser extent, can forage while swimming. Thus, these birds are able to use the entire surface area of a pond, taking advantage of prey near the surface of the water. Phalaropes can draw invertebrates from deeper water upward in the water column by spinning on the water's surface. However, much of the invertebrate biomass of the mid- and high-salinity salt ponds may still occur at depths greater than those that can be used by these shorebirds (Laine, pers. comm.). Although brine shrimp account for most of the biomass of the invertebrates within these high-salinity ponds, the nutritive value of brine shrimp to foraging shorebirds may be limited, as Rubega and Inouye (1994) found that red-necked phalaropes could not survive foraging on brine shrimp alone. Brine flies (both adults and larvae), and water boatmen to a lesser extent, are thus very important to shorebirds that forage in South Bay salt ponds (Anderson 1970).

Most vegetated tidal marsh receives little use by foraging shorebirds because of the height and/or density of marsh vegetation. However, more open areas within the marsh are used for foraging by some species. Willets forage in the vegetated portions of tidal marshes (Gerstenberg 1979; Kelly and Cogswell 1979; Long and Ralph 2001), particularly when these areas are flooded during very high tides but occasionally even during low tide (Kelly and Cogswell 1979). Long-billed curlews, marbled godwits, least sandpipers, and other species occasionally forage in vegetated tidal marsh areas as well, usually in more sparsely vegetated areas but occasionally in dense (but short) pickleweed. Large numbers forage on intertidal flats

along the larger sloughs within marshes when the flats are exposed, but most shorebirds avoid areas with dense, tall vegetation, and therefore do not forage in most of the marsh plain. These birds will forage, sometimes abundantly, in shallow marsh ponds and pannes within the high marsh, and in areas where bare mud and shallow water is interspersed with short pickleweed vegetation. Stralberg et al. (2003) reported that the proportion of small shorebirds foraging (rather than roosting) was higher in tidal marsh than in salt ponds. Thousands of individuals of a variety of species use New Chicago Marsh, a managed marsh (i.e., not considered a tidal marsh) in Alviso, for foraging at both low and high tide, as this marsh provides extensive shallow-water marsh pond/panne habitat interspersed with low pickleweed. However, most such areas that formerly occurred within South Bay tidal marshes have been destroyed by fill and diking, and at this time, high marsh habitat within fully tidal marshes is of limited importance for foraging shorebirds in the South Bay.

Birds are often classified by their foraging methods and habitats, which are largely a reflection of their physical adaptations for foraging and their preferred prey, into foraging groups or guilds. As indicated in the USGS unpublished preliminary bird data from Alviso salt ponds, shorebirds in the South Bay are generally grouped into three foraging guilds – shallow probers, deep probers, and sweepers.

Shallow probers are species that pick prey off the surface of the water or sediment (generally after locating the prey visually), or that probe at shallow depths within mud or moist sand to locate prey tactilely. The more common shallow probers in the South Bay include the killdeer, black-bellied plover, semipalmated plover, snowy plover, red knot, dunlin, least sandpiper, and western sandpiper. This guild represents the majority of the migrant and wintering shorebirds in the South Bay, with hundreds of thousands of western sandpipers, tens of thousands of least sandpipers and dunlin, thousands of black-bellied plovers and semipalmated plovers, and hundreds of snowy plovers and red knots using the South Bay at times (Harvey et al. 1992; Stenzel et al. 1989; Stenzel and Page 1988). Warnock and Bishop (1998) have identified the San Francisco Bay as a major staging area for the western sandpiper because individuals are present for longer periods of time and presumably put on more fat than in the stopover areas that are used, but are less important, elsewhere along the central California coast. The western sandpiper is by far the most abundant shorebird species present in the South Bay.

Deep probers include species generally having larger bodies and longer legs and bills than the shallow probers. These species, which probe more deeply into moist sediment and burrows for prey and do less picking of items from the surface (except for yellowlegs), include short-billed dowitchers (*Limnodromus griseus*), long-billed dowitchers, long-billed curlews, marbled godwits, whimbrels (*Numenius phaeopus*), and willets. Though not nearly as abundant in the South Bay as the shallow probers, this guild is still represented by tens of thousands of dowitchers, 10,000+ willets and marbled godwits, and hundreds of long-billed curlews, whimbrels, and greater and lesser yellowlegs during migration and winter (Harvey et al. 1992; Stenzel et al. 1989; Stenzel and Page 1988). The salt pond surveys by USGS identified the highest abundance of both shallow and deep probers (the vast majority of which were likely roosting, rather than foraging, in these ponds) in Alviso Ponds A5 and A7 (Takekawa et al. 2005).

Sweepers include the American avocet, black-necked stilt, Wilson's phalarope, and red-necked phalarope. All of these species forage by picking visually identified prey from the soil surface or water column, but

avocets also forage by sweeping their bills from side to side through water and mud, tactilely detecting prey. Phalaropes may create a vortex by spinning in the water and drawing prey to the surface. In the South Bay, breeding populations of American avocets and black-necked stilts are augmented in winter, when up to 24,500 avocets and 11,500 stilts are present (Harvey et al. 1988). High counts of phalaropes in the South Bay include counts of 37,462 Wilson's phalaropes on 6 August 1984 and 19,000 red-necked phalaropes on 18 August 1981 (Harvey et al. 1992), with combined phalarope counts of as many as 70,000 individuals (Harvey et al. 1988). Both species are much less common in spring than in late summer and fall in the South Bay. Due to the presence of the South Bay salt ponds, the San Francisco Bay is one of five major staging areas for adult Wilson's phalaropes prior to their non-stop migration to South America (Colwell and J.R. Jehl 1994). The salt pond surveys by USGS identified the highest abundance of sweepers in Alviso Ponds A1, A5, A7, A8, A9, A14, A16, and AB2 (Takekawa et al. 2005).

Shorebirds in the South Bay eat a wide variety of invertebrates, and occasionally small fish. Brine shrimp, brine flies, and reticulate water boatmen probably compose the bulk of the prey taken in salt ponds, although *Corophium* spp., annelids, polychaetes, and other invertebrates are known to be taken in salt ponds as well (Anderson 1970). *Corophium* spp., polychaetes, bivalves, and snails likely compose the bulk of the prey taken on mudflats (Harvey et al. 1992; Recher 1966; Swarth et al. 1982). Shorebirds are very flexible and opportunistic in their diets, with considerable dietary overlap among species and foraging guilds (Skagen and Oman 1996). They often take prey in accordance with availability, concentrating where prey is most dense (Goss-Custard 1970; Goss-Custard 1977; Goss-Custard 1979). Thus, the hydrologic regimes and ecosystem processes that maintain abundant invertebrate populations are more important than the specific invertebrate taxa available. As a result, shorebirds are still abundant in the South Bay, and still show a preference for foraging on intertidal mudflats, despite the widespread and pervasive invasions of the South Bay benthic invertebrate community by nonnative species.

Roosting. Shorebirds generally roost, resting and preening, when they are not foraging. Many mudflat specialists roost on the upper flats after initially foraging on the receding tide, then fly to alternate habitats to roost as the mudflats flood. In the South Bay, the most commonly used high-tide roosts for both pond specialists and mudflat specialists are shallows and bare sediment within salt ponds, levees surrounding and (especially) between salt ponds, and islands and artificial structures such as boardwalks within these ponds (Warnock et al. 2002). Surveys coordinated by SFBBO in 1992 and 1993 (Hanson and Kopec 1994) found that 28% of all birds were in shallow water of salt ponds at high tide (most roosting), with an additional 23% on islands within salt ponds and another 10% on levees around a variety of habitats, including salt ponds. Islands within salt ponds were found to be used primarily for roosting, whereas shallow water within salt ponds was used by similar numbers for foraging and roosting. Levees were used for roosting more in spring than in winter, and infrequently in fall.

Although some shorebirds forage at high tide within salt ponds, most birds, including both pond specialists and mudflat specialists, roost during high tide (Hanson and Kopec 1994; Warnock et al. 2002). Major high tide shorebird roosts in the South Bay, based on the unpublished preliminary USGS bird survey data and SFBBO's 1992-1993 study (Hanson and Kopec 1994), are indicated on Figure 3, which also depicts the sites of major western sandpiper roosts in the South Bay identified by Warnock and Takekawa (1995).

Shallowly flooded marsh ponds, marsh pannes, managed marshes, managed ponds, and water treatment plant drying ponds are also used for roosting, and American avocets, willets, long-billed curlews, marbled godwits, dunlin, and dowitchers roost to some extent in tidal marshes with short vegetation (PRBO Conservation Science 2004; Storer 1951). Diked and tidal marshes along the Foster City/Redwood Shores shoreline provide roosting sites for large numbers of birds at times, particularly larger species such as willets, marbled godwits, and black-bellied plovers (Hanson and Kopec 1994).

Due to their proximity to foraging habitat, protection from predators, and protection from wind and wave action, some high-tide roosts are used consistently, and studies of color-marked or radio-tagged shorebirds in the South Bay indicate that many individuals use the same roosting sites consistently (Kelly and Cogswell 1979; Warnock and Takekawa 1995). Other shorebird roosts, however, may be more ephemeral or inconsistently used (Colwell et al. 2003). For foraging shorebirds, site fidelity is tied to consistently suitable conditions at certain locations (e.g., certain ponds that consistently provide shallow foraging habitat for shorebirds) rather than the locations themselves. While the same is likely true of shorebird roost sites, fidelity to a roost site is less easily explained given the abundant, widespread nature of ostensibly suitable roosting habitat on salt pond levees throughout the South Bay.

Waterfowl. Historical accounts of waterfowl numbers in the San Francisco Bay area attest to the abundance of ducks and, to a lesser extent, geese using the Bay area during migration and winter; for example, more than 300,000 ducks were sold in San Francisco markets during the 1911-1912 waterfowl season (Skinner 1962). The South Bay undoubtedly supported large wintering waterfowl populations, as reported by Skinner (1962) for the Alvarado area and the Santa Clara Valley, and the town of Drawbridge near Alviso “became a resort solely for duck hunters arriving from San Francisco by regular trains in the 1880s” (Harvey et al. 1992). The loss of 90% of the Bay’s wetlands, along with hunting pressures, contamination, and other factors led to a decline in waterfowl populations, although this decline is not well documented for the South Bay. Currently, the South Bay supports fairly large migrant and wintering populations of ducks, with several breeding species as well.

More than 32 species of waterfowl use the baylands and immediately adjacent habitats of the South Bay. Of these, eight species breed regularly (with populations augmented considerably during the nonbreeding season), nine additional species occur regularly during migration and winter, and at least 15 more occur irregularly and/or in very low numbers in the baylands as nonbreeders. Harvey et al. (1988) reported that wintering waterfowl in the South Bay (south of the San Mateo Bridge) in 1981 exceeded 75,000 individuals, with more ducks on salt ponds than in the Bay, especially from January through April. Surveys in 1987-1990 revealed approximately 57,000 dabbling ducks (ducks that feed without submerging their entire bodies) and 220,000 diving ducks (Goals Project 1999) in the Bay area. The South Bay salt ponds were found to support up to 76,000 wintering waterfowl, representing more than one-quarter of the Bay’s waterfowl population, including 89% of the Bay’s northern shovelers, 67% of the ruddy ducks, half of the buffleheads, and 17% of the canvasbacks wintering in the Bay (Accurso 1992; Takekawa et al. 2000).

Breeding. Though not nearly as important to nesting waterfowl in the Bay Area as the Suisun Bay (Goals Project 1999; Harvey et al. 1992), the baylands habitats of the South Bay support eight regularly nesting waterfowl species: the mallard, gadwall, and Canada goose (breeding populations of which are introduced) are fairly common breeders, while the cinnamon teal, northern pintail (*Anas acuta*), ruddy duck, lesser scaup, and northern shoveler breed in smaller numbers. Several other species, including the green-winged teal (*Anas crecca*), blue-winged teal (*Anas discors*), canvasback (*Aythya valisineria*), and redhead (*Aythya americana*), have been recorded breeding only a few times in the Study Area (Santa Clara County Bird Data Unpublished).

Few data exist on breeding population estimates for these waterfowl species in the South Bay. The most comprehensive survey and population estimate for this area was by Gill (1977). During the 1971 breeding season, he found 21 nests or broods of the northern pintail, 19 of the gadwall, eight of the mallard, five of the ruddy duck, four of the cinnamon teal, and one of the northern shoveler in the South Bay. Based on his observations, Gill estimated breeding populations of these species at 50-100 pairs of pintails, 100-150 pairs each of gadwalls and mallards, 50-100 pairs of ruddy ducks, 75-100 pairs of cinnamon teal, and one to five pairs of shovellers in the South Bay. Based on breeding bird atlas work and other observations by birders, current populations of these species likely exceed Gill's 1971 estimates. For example, 650 gadwalls (including 25 broods of young) on 24 July 1993 at the Sunnyvale WPCP (Steve Rottenborn, pers. obs.) attest to much higher breeding abundance than was estimated by Gill. In addition, the lesser scaup has become a regular breeder (albeit in low numbers, likely ten to 20 pairs or more) in the South Bay since Gill's studies (Santa Clara County Bird Data Unpublished).

None of the 41 nesting attempts observed by Gill in salt marsh was successful, leading him to postulate that breeding populations in the South Bay were limited by the availability of freshwater habitats. The nesting microhabitats of these waterfowl within the South Bay are poorly known since nests are usually well hidden, and most breeding is detected by the observation of adults with broods of precocial young. Nesting by most of these species likely occurs in dense herbaceous vegetation in the upper tidal marsh, managed wetlands, upland transition areas, ruderal vegetation on levees, and upland areas surrounding ponds, sloughs, and ditches, such as weedy lots and fields. In contrast, the ruddy duck builds its nests in emergent vegetation in freshwater marshes and the marshy borders of freshwater ponds and ditches.

Important breeding areas for waterfowl in the South Bay combine freshwater or brackish seasonal wetlands with extensive grassy or ruderal vegetation for nesting and fresh, brackish, or low-salinity ponds and marshes for brooding of young. Such areas occur in the Study Area in the Palo Alto Flood Control Basin and vicinity, the Moffett Field/Crittenden Marsh area, the Sunnyvale and San Jose-Santa Clara WPCPs, the Sunnyvale Baylands, and the Coyote Creek Reach 1A waterbird pond.

Foraging and Roosting. The South Bay is an important foraging area for migrant and wintering waterfowl. All of the breeding species are present in much greater abundance during the nonbreeding season than during summer, and they are joined by other species that occur in the South Bay solely as nonbreeders. Duck abundance in the South Bay increases in August and September as migrants, particularly northern shovellers, arrive in salt ponds and marshes. Numbers of other dabbling ducks and

several species of diving ducks increase through the fall and into winter, and remain high into March (Santa Clara County Bird Data Unpublished; Takekawa et al. 2005).

Dabbling ducks forage in a variety of habitats in the South Bay, including mudflats, shallow subtidal habitats, tidal sloughs and marsh channels, marsh ponds, managed and muted tidal marsh, seasonal wetlands, managed ponds, and water treatment plants. In these areas, dabbling ducks feed on a variety of aquatic plants and invertebrates. Because these species do not typically dive for food, dabbling ducks usually forage in water less than 30 centimeters deep (Page 2001). Within salt ponds, salinity is also important for these birds. The plants on which many dabbling ducks feed cannot tolerate high salinities, and thus dabbling duck abundance tends to be highest on lower salinity ponds (20-63 ppt) ponds, with few in ponds >154 ppt (Accurso 1992).

The most abundant dabbling ducks wintering in the South Bay are the northern shoveler, American wigeon (*Anas americana*), northern pintail, mallard, and gadwall (Takekawa et al. 2005). Shovelers are both abundant and flexible in habitat use in the South Bay, although they do not use tidal habitats frequently (Swarth et al. 1982). The northern shoveler was the third most abundant species recorded at the Coyote Creek Reach 1A waterbird pond during monitoring from 1992 to 2003, composing 81% of the waterfowl recorded there (Strong 2003), and counts of 4750 (19 Dec 1999) at the San Jose-Santa Clara WPCP and 5500 (20 December 1996) at the Sunnyvale WPCP have been recorded (Santa Clara County Bird Data Unpublished). Swarth et al. (1982) found shovelers to be much more abundant on salt ponds than in tidal habitats, with 16,500 shovelers counted on two salt ponds during a census in early November. In contrast, these observers found American wigeon, canvasback, scaup, and surf scoters to be much more abundant on the Bay than in salt ponds. Ruddy ducks and northern pintails were common in both habitats.

Diving ducks are the most abundant wintering waterfowl in the South Bay. Common species include the lesser scaup, greater scaup (*Aythya marila*), ruddy duck, canvasback, bufflehead (*Bucephala albeola*), surf scoter, common goldeneye (*Bucephala clangula*), and red-breasted merganser (*Mergus serrator*). These species may “tip up” for food in shallow water, but more frequently dive completely underwater to obtain food. Bivalves, including large numbers of Baltic clams, are a favored food item for diving ducks such as scaup, canvasbacks, and surf scoters, and canvasbacks often congregate over bivalve beds (Miles 2000b; Takekawa and Marn 2000; White et al. 1988). Ruddy ducks forage on aquatic vegetation (such as wigeon grass), which grows primarily in lower-salinity ponds, and invertebrates, including mollusks and water boatmen (Anderson 1970; Miles 2000a). Brine fly larvae/pupae are important to lesser scaup foraging on South Bay salt ponds (Anderson 1970).

Diving ducks are common in the open waters of the Bay, where large flocks of lesser and greater scaup, canvasbacks, and other species often congregate to roost. Although diving ducks may forage in water up to ten meters deep (Miles 2000b), these birds forage primarily in water only a few meters deep (John Takekawa, pers. comm.), and therefore much of the Bay is not available to (or does not provide high-quality foraging conditions for) these birds for foraging, and foraging flocks of diving ducks tend to congregate over shoals and over intertidal flats when they are inundated at high tide. Diving ducks are

also common on salt ponds, in larger sloughs, and on some artificial lakes, such as Shoreline Lake in Mountain View.

Surveys conducted between October 1987 and March 1988 found that scaup composed 41%, scoters 21%, northern shovelers 11%, ruddy ducks 9% and canvasbacks 6% of all waterfowl on the open waters of the Bay (Takekawa et al. 1988). A large percentage (up to 25% or more) of the Bay's wintering populations of scaup and surf scoters occur in the South Bay, but most forage on the Bay itself, whereas buffleheads and ruddy ducks forage more extensively in salt ponds (Takekawa et al. 1988). Conducting winter censuses (November 2000 – February 2001) of the Bay south of the Bay Bridge, Ford et al. (2002) estimated more than 168,000 scoters, 164,000 scaup, and 53,000 ducks of other species on the open waters of the Bay. Although the center of abundance moved around somewhat among surveys, the greatest concentrations of scoters were north of the San Mateo Bridge, while several centers of abundance for scaup included areas between the Dumbarton and San Mateo Bridges and south of the Dumbarton Bridge.

Although total numbers of waterfowl are higher on the Bay than in salt ponds in the South Bay, lower-salinity salt ponds (20-63 ppt) of moderate size (50-175 ha) support the highest densities of waterfowl in the Study Area (Siegel and Bachand 2002). Ponds A9 and A10 in Alviso, and the Sunnyvale WPCP ponds, have been identified as being particularly important to northern pintail populations in the South Bay (Casazza and Miller 2000). Results of the salt pond surveys by USGS (Takekawa et al. 2005) indicate that in the Alviso Complex, Ponds A1, A2E, A2W, A5, A7, A9, and AB2 support high numbers of dabbling ducks, with the higher salinity Ponds A12, A13, and A19-A23 supporting few dabblers. Ponds A1, A2W, A9, and A10 support large numbers of diving ducks, primarily ruddy ducks and scaup, with fewer buffleheads and canvasbacks.

On decommissioned salt ponds in the North Bay, Takekawa et al. (2004) found that diving benthivores, primarily diving ducks, dominated the bird community on the salt ponds. Diving duck densities were four times higher in salt ponds than in the natural baylands in winter and spring, as contrasted with dabbling ducks, which were consistently higher in baylands habitats than in salt ponds. In South Bay salt ponds, dabbling ducks tend to dominate the salt pond bird communities, with northern shovelers accounting for 41-46% of all birds in ponds at low tide (Warnock et al. 2002). Ruddy ducks are the next most abundant duck wintering on South Bay salt ponds (primarily on low-salinity ponds), with up to 19,000 recorded on these ponds (Accurso 1992). In contrast to shorebirds, the vast majority of which use salt ponds primarily at high tide, duck numbers on South Bay salt ponds are similar at high and low tides (Warnock et al. 2002).

Stralberg et al. (2003) found that dabbling duck species richness in the South Bay tended to be higher in marshes than in salt ponds, and that dabbling ducks were more abundant in marshes at low tide, while diving ducks were more abundant at high tide. Dabbling ducks reached peak densities in salt ponds in fall and early winter, while diving ducks peaked in early spring. Dabbling duck densities tended to be higher in salt ponds with more natural upland, less tidal marsh, and less development surrounding the pond, while diving ducks tended to be higher in ponds closer to the Bay. Ninety percent of the dabbling ducks

recorded during this study were recorded in just six of 22 ponds, while 90% of the diving ducks were recorded in nine ponds, indicating that the majority of ponds support few ducks.

Diving ducks, and many dabbling ducks, often roost while swimming in the open waters of the Bay, on sloughs, and in salt ponds. Dabbling ducks, and diving ducks to a lesser extent, also roost on the edges of mudflats and marshes, on islands and levees within ponds, and on mud and shallow water within the bottoms of salt ponds.

Large waders and other piscivores. This category includes a diverse group of approximately 20 species of piscivorous (i.e., fish-eating) waterbirds that occur in the South Bay, including pied-billed grebes (*Podilymbus podiceps*), western grebes (*Aechmophorus occidentalis*), Clark's grebes (*Aechmophorus clarkii*), loons (which are uncommon to rare visitors), double-crested cormorants, American white pelicans, brown pelicans (*Pelecanus occidentalis*), and large waders (i.e., herons, egrets, and ibis). Several other species, including gulls, terns, mergansers, and belted kingfishers (*Ceryle alcyon*) also forage for fish in the Study Area but are treated in other categories.

While a number of piscivores breed in the South Bay, numbers of most of these species are highest during the nonbreeding season. Western and Clark's grebes do not nest in the baylands of the South Bay but may occur in the area, particularly on salt ponds and in the open Bay, year-round (being most abundant in winter). Brown pelicans typically occur in San Francisco Bay as post-breeding dispersants during summer and fall (Ainley 2000a). American white pelicans are most abundant from June through December.

Breeding. Several piscivorous species in this category nest in the South Bay. Pied-billed grebes nest in freshwater wetlands, building floating nests of vegetation, in scattered areas surrounding the salt ponds and tidal wetlands in the Study Area. Double-crested cormorants nest on electrical transmission towers at several locations in the Study Area, and on the levee between Ponds A9 and A10 in Alviso (see Figure 5); this species and the white-faced ibis (*Plegadis chihi*) are discussed in greater detail in the Special-Status Wildlife Species section below (Section 3.7).

Herons and egrets nest in the Study Area as well (Figure 4). A sizeable colony of waders was detected at Mallard Slough in Alviso in the mid 1970s (Harvey et al. 1992). This colony steadily increased in size, peaking at over 800 nests, through the 1990s. Ten nesting pairs of great egrets were discovered in 1977, increasing to 30 pairs in 1990, when an estimated 266 pairs of snowy egrets and 115 pairs of black-crowned night-herons were present. Up to nine pairs of cattle egrets (*Bubulcus ibis*) and one or more pairs of little blue herons (*Egretta caerulea*) and white-faced ibis also nested in the Mallard Slough colony in the early 1990s. However, this colony was abandoned for unknown reasons in 1999. That year, a small colony of great egrets, containing up to 30 adults and eight nests, became established nearby along lower Coyote Creek near the Reach 1A waterbird pond. Twelve great egret nests were found here in 2000, and seven pairs of great blue herons nested at this location in 2001 (Santa Clara County Bird Data Unpublished). However, this colony has since been abandoned.

Since 1998, small heron rookies have appeared on islands in inland reservoirs in the South Bay (e.g., Lake Cunningham, Almaden Lake, and Vasona Reservoir), and several other small colonies have appeared in the immediate Study Area. Currently, heron rookeries in the vicinity of the Alviso Complex include a colony of snowy egrets and black-crowned night-herons at the Palo Alto Baylands duck pond; small numbers of great blue herons nesting on transmission towers in Ponds A2W, A2E, A3N, and A19 (and on a duck blind in Pond A2E); great egrets, snowy egrets, and black-crowned night-herons nesting in California bulrush at the west end of the Coyote Creek Lagoon near Newby Island (first noted in 2000); and great egrets, snowy egrets, black-crowned night-herons, and little blue herons in Guadalupe Slough between ponds A4 and A5 (Santa Clara County Bird Data Unpublished; Strong 2004a). Green herons (*Butorides virescens*) nest at low densities in scattered locations throughout the South Bay, including mixed-species heronries but also as isolated pairs or in small monospecific groups on duck blinds, along sloughs, and in trees and brush.

Foraging and Roosting. The piscivorous birds of the South Bay forage in a variety of habitats and locations where prey fish are available. The low-salinity salt ponds that support fish, tidal sloughs and channels, edges of intertidal mudflats, nontidal ponds and channels, and artificial lakes such as Shoreline Lake provide the highest-quality foraging areas, and large frenzies of feeding activity may be observed at these locations, presumably when conditions result in large fish concentrations. Brown pelicans usually plunge-dive for fish and therefore require water several feet deep, but American white pelicans and cormorants swim while feeding and can thus feed in shallower water. Although double-crested cormorants, western and Clark's grebes, and brown pelicans forage to varying degrees within the open waters of the Bay, American white pelicans apparently do not, instead preferring nontidal waterbodies (Cogswell 2000; Harvey et al. 1988). Large wading birds are constrained by water depth, and are usually seen foraging from the edges of a body of water or wading within the shallows. Pied-billed grebes and most of the herons and egrets often forage along freshwater streams and in smaller ponds in the South Bay, and great blue herons and great egrets occasionally forage for small mammals in upland fields and ruderal areas.

The larger piscivores move around the South Bay in search of suitable foraging conditions, allowing them to exploit particularly large concentrations of fish. Cormorants and pelicans exhibit movements between foraging areas at inland reservoirs and the South Bay, although most foraging likely occurs within the baylands habitats (Steve Rottenborn, pers. obs.). Piscivore density tends to be lower in salt ponds at low tide than at high tide, as some birds move to intertidal flats to forage (e.g., herons and egrets) or roost (e.g., pelicans) at low tide (Stralberg et al. 2003).

Within salt ponds, the fish commonly taken by piscivores include the mudsucker, topsmelt, sculpin, and stickleback (Cogswell 2000; Harvey et al. 1988). These fish are usually found in water having salt concentrations up to 70-80 ppt, and most cannot tolerate salinity >40 ppt (Carpelan 1957; Lonzarich 1989). As a result, most piscivore use of salt ponds is concentrated in ponds with lower salinities (Anderson 1970; Swarth et al. 1982).

Swarth et al. (1982) reported that loons and western and Clark's grebes were much more abundant on the Bay than in the salt ponds west of the Coyote Hills (Swarth et al. 1982), noting that piscivorous species

were more common in the Alviso ponds than in the Coyote Hills ponds. Approximately 94% of the pelicans and double-crested cormorants recorded by Swarth et al. (1982) were in low-salinity ponds, though most of the cormorants used these ponds only for roosting (primarily on wooden pilings and platforms within the ponds). Although cormorants may take advantage of local concentrations of fish within salt ponds, most apparently feed in the Bay (Ainley 2000b; Anderson 1970). Herons and egrets forage primarily in sloughs and marshes, with only some birds moving to salt ponds at high tide (Anderson 1970; Swarth et al. 1982). However, where temporary concentrations of fish were present (generally in low-salinity ponds in fall), these waders occurred in large concentrations. Takekawa et al. (2001) reported that piscivores were more abundant in natural baylands than in salt ponds in the North Bay during all seasons, while Stralberg et al. (2003) determined that the species richness of large waders tended to be higher in the tidal salt marsh than in salt ponds, although piscivore abundance was higher in salt ponds.

Aerial surveys of the South Bay salt ponds have recorded counts of up to 3147 (on 6 August 1984) American white pelicans using these ponds (Harvey et al. 1992). These surveys only found white pelicans using ponds with salinities between 25 and 90 ppt, with the highest densities in ponds with low salinities (25-30 ppt). Harvey et al. (1992) suggested that the conversion of tidal marsh to salt ponds has benefited white pelicans, and that populations of nonbreeders in the Bay have increased as a result of the provision of sheltered foraging areas that concentrate fish and undisturbed levees for roosting.

Surveys of the South Bay salt ponds by USGS (Takekawa et al. 2005) indicate that species richness of piscivores is more or less constant throughout the year, though abundance is highest in late summer and fall due to the presence of high numbers of herons, egrets, and American white pelicans foraging in salt ponds at this time. Within the Alviso Pond Complex, piscivore abundance is highest in Ponds A1, A2W, A3W, A5, A7, A9, A10, and AB2 and very low in Pond B6 (which contains little water) and the high-salinity ponds A19-A23.

grebes and loons roost entirely on the water, and other swimming piscivores (e.g., pelicans and cormorants) may form floating roosts as well. However, most roosting by pelicans and cormorants occurs on salt pond levees (particularly interior levees between ponds), islands, and artificial structures such as boardwalks. Cormorants often roost in flocks on transmission towers as well. Herons and egrets roost on salt pond levees and in dense marsh vegetation along tidal sloughs.

Larids. Although larids (i.e., birds in the family Laridae, such as gulls, terns, and skimmers) have always used the South Bay for foraging during winter and migration, the use of this area has undoubtedly increased as a result of salt pond creation and, for gulls, the provision of food at landfills, and several species have begun nesting in the South Bay over the last century as a result. Currently, larid populations in the Bay are highest in winter due to the presence of tens of thousands of (if not 100,000+) wintering gulls. However, terns are generally more abundant in the South Bay during the breeding season. Information on special-status larids in the South Bay, including the California gull, California least tern, and black skimmer, can be found in the Special-Status Wildlife Species section below (Section 3.7).

Breeding. In the early 1900s, the Caspian tern was the only larid known to nest in the San Francisco Bay area, with a colony of more than 100 pairs nests present as early as 1916 in marshes near the east end of the Dumbarton Bridge (Grinnell and Miller 1944; Grinnell and Wythe 1927). This colony was reported to occur on a dike between salt ponds as of 1952 (Sibley 1952). As this colony grew to a size of 200 pairs, it split into two colonies in the Newark/Eden Landing area, and a third colony became established on salt pond levees near Mowry Slough in the late 1960s. By 1981, a colony of 1000 pairs was present on Bair Island as well, with approximately 2350 nesting birds present in the South Bay (Rigney and Rigney 1981). However, predation and disturbance by red foxes caused the abandonment of both the Mowry and Bair Island colonies in 1990 and 1991. Subsequently, Caspian terns nested in small numbers at Bair Island in 1993 and 1994 (Harding et al. 1998). Since 1990, breeding within the Study Area has also occurred in Pond A7 (breeding 1997-2006, peaking at 195 individuals in 2001 but with only 30 in 2006) and Ponds A9/A10 (70 individuals present in 1992 only). All nesting in the South Bay currently occurs on isolated portions of levees and islands with little or no vegetation within salt ponds. Although South Bay populations have declined precipitously since the early 1980s, the establishment of a large colony on Brooks Island in the North Bay has allowed Bay-area populations to remain fairly constant, with approximately 2300 individuals breeding in the Bay area in 2003 (Strong 2004a).

Forster's terns were not reported to be nesting in the San Francisco Bay area as of 1944 (Grinnell and Miller 1944), but a colony containing approximately 100 nests was discovered near the east end of the San Mateo Bridge in 1948 (Sibley 1952). Another colony was detected near the east end of the Dumbarton Bridge in 1952, and since then, Forster's tern colonies have appeared at scattered locations throughout the South Bay, with populations peaking at 4386 birds in 1992. However, local populations of Forster's terns have declined significantly since 1984, and a 2003 estimate of the Bay-wide population stands at 2450 individuals (Strong 2004a). In 2003, the 1958 Forster's terns thought to be nesting in the South Bay represented 80% of the total San Francisco Bay population, and represented nearly 25% of the Pacific Coast population and 10% of the North American population estimated in 2001 (McNicholl et al. 2001; Strong et al. 2004a).

Since 1990, Forster's tern colonies have been recorded in the Study Area at the following locations (Figure 4): Charleston Slough and the Palo Alto Flood Control Basin; Alviso Ponds A1, A5, A6, A7, A8, A9/A10, A16, A17, A18, and AB2. These colonies are located on small islands having little or no vegetation (and no tall vegetation) within salt ponds, tidal flats (at Charleston Slough), and managed marsh (Palo Alto Flood Control Basin), with small numbers on duck blinds. In 2006, the largest colonies within the Study Area were at Pond A7 (170 nests) and Pond A16 (132 nests; Strong 2006).

Predation by red foxes, and by avian predators such as California gulls and common ravens (*Corvus corax*), may be impacting tern populations to some extent. In addition, encroachment on Forster's tern nesting sites by an ever-increasing California gull breeding population in the South Bay has taken its toll on nesting terns; for example, islands in Alviso Pond AB2 that were formerly used by nesting Forster's terns have been largely, or entirely, taken over by nesting gulls (Strong 2004a). Because nesting on islands is so important to Forster's terns and black skimmers (and secondarily to the other breeding larids in the South Bay) to deter mammalian predation, population sizes may be limited by available breeding sites.

Least terns, black skimmers, and California gulls are also recent additions to the breeding avifauna of the South Bay; these species are discussed in detail in the Special-Status Wildlife Species section below (Section 3.7). Western gulls (*Larus occidentalis*) nest in very low numbers in the Study Area, with one to three pairs nesting in Pond A6 and on the levee between Mowry Ponds M4 and M5, both within large California gull colonies (Strong 2004a, Strong 2006). The western gull breeds much more commonly near the mouth of the Bay and along the coast.

Foraging and Roosting. Terns and skimmers in the South Bay, which include not only the aforementioned species, but also post-breeding elegant terns (*Sterna elegans*) and occasionally common terns (*Sterna hirundo*), feed primarily on small fish. Foraging occurs commonly within the open waters of the Bay and in low-salinity salt ponds, as well as tidal sloughs and freshwater and brackish channels and ponds. Caspian and Forster's terns often forage at inland ponds and lakes as well, even during the breeding season. Terns may roost on intertidal mudflats at low tide, whereas at high tide and at night they roost primarily on isolated levees, islands, and exposed mud surrounded by water within shallow ponds.

During the nonbreeding season, nesting populations of western and California gulls within the South Bay are augmented not only by nonbreeders of those species (likely including 10,000+ more California gulls and hundreds to 1000+ western gulls), but also by large numbers of herring (tens of thousands), Thayer's (*L. thayeri*; thousands), ring-billed (*L. delawarensis*; thousands to 10,000+), mew (*L. canus*; thousands), glaucous-winged (*L. glaucescens*; hundreds to 1000+), and Bonaparte's (thousands) gulls. With the exception of the Bonaparte's gull, which forages primarily on invertebrates in salt ponds and sewage treatment plants, these gulls are opportunistic foragers. They eat a wide variety of animal matter, including invertebrates, fish, small mammals and birds, and carrion, as well as processed food in landfills. Many gulls forage or roost on intertidal mudflats at low tide (Warnock et al. 2002).

The Newby Island landfill north of Coyote Creek near Alviso in the Study Area and the Tri-Cities Recycling and Disposal Facility located in Fremont immediately adjacent to the Study Area provide food for tens of thousands of wintering gulls, and are likely primarily responsible for the large wintering (and possibly breeding) populations of gulls in the South Bay. Gull abundance is much higher in the vicinity of these landfills than elsewhere in the Study Area, and particularly large concentrations of roosting birds occur in the Alviso and Fremont salt ponds. For example, the location of Ponds A22 and A23 between these two large landfills makes them a particularly attractive roosting location for gulls in winter. California gulls forage extensively at landfills in the South Bay, but they (and mew gulls to some extent) also forage in large numbers on brine flies and other invertebrates within mid- and high-salinity salt ponds, like the Bonaparte's gull (Steve Rottenborn, pers. obs.). Up to 10,000 Bonaparte's gulls forage in the South Bay, primarily on brine shrimp and brine flies in salt ponds having salinities of 90-200 ppt (Harvey et al. 1992). The recent surveys of South Bay salt ponds by USGS (Takekawa et al. 2005) found Bonaparte's gull abundance highest on Alviso Pond A8.

Most of the gulls in the greater South Bay area roost on the Bay or salt ponds/levees at night and large numbers roost in these areas during the day as well. Thousands of gulls disperse inland from the Bay area

during the day to forage at inland landfills, on agricultural fields and seasonal wetlands, on athletic fields, and in urban areas, particularly in winter.

Carpelan (1957) indicated that Forster's terns are the main predator on topsmelt in South Bay salt ponds, and Anderson (1970) also suggested that the topsmelt was likely the main prey item of Forster's terns in the South Bay. A study of the diet of breeding Forster's terns in the South Bay in 1972 (Anonymous Unpublished) found that their diet consisted primarily of fish; many were caught in the Bay, but a large percentage was caught in lower-salinity salt ponds as well. Fish most frequently taken at these ponds included small (<six centimeters) Pacific herring (which were often fed to chicks), topsmelt, and anchovies. Observations of adults with prey at four Forster's tern colonies in the South Bay indicated that threespine stickleback outnumbered all other fish combined by an order of magnitude, with several thousand sticklebacks observed as prey. The next five most abundant fish brought to colonies were northern anchovy (90 individuals), topsmelt (82), staghorn sculpin (64), shiner surfperch (50) and dwarf surfperch (*Micometrus minimus*, 45). Ten other fish species, all represented by 27 individuals or fewer, were also used as prey, as well as four individuals of two genera of bay shrimp.

Gill (1976) recorded 21 species of fish found at the Mowry colony of Caspian terns during the 1971 breeding season. The eight species representing greater than 2% of the total number of fish recorded were jacksmelt (33%), shiner perch (16%), staghorn sculpin (16%), longjaw mudsucker (9%), Oriental goby (5%), northern anchovy (6%), rainbow trout (4%), and topsmelt (3%). While the vast majority of fish recorded at this colony were estuarine species, seven species were primarily freshwater fish. The observation of Caspian terns with tagged trout that had been released at Del Valle Reservoir, 25 miles away from the Mowry tern colony, exemplifies this terns' propensity for foraging widely during the breeding season.

Other Waterbirds (eared grebes, coots, and rails). The eared grebe and South Bay members of the family Rallidae, which includes the American coot (*Fulica americana*), common moorhen (*Gallinula chloropus*), and several species of rails, are combined into a separate group for the purposes of this existing conditions report.

The eared grebe is a small diving bird that breeds only occasionally and in small numbers in the South Bay, occurring much more abundantly as a nonbreeding forager from October to April. Eared grebes nest in California on freshwater wetlands in the Central Valley and Great Basin regions fairly commonly, but in the South Bay, breeding has occurred only in a flooded, diked pickleweed marsh in the Moffett Field/Crittenden Marsh area, where nesting occurred in 1983, 1986, 1993, and 1995 (Cogswell 2000; Santa Clara County Bird Data Unpublished).

Nonbreeding eared grebes in the South Bay are closely tied to deeper, higher-salinity salt ponds, where they feed on brine shrimp, brine flies, and reticulate water boatmen (Anderson 1970). Censuses of eared grebes on South Bay salt ponds have exceeded 40,000 individuals (Harvey et al. 1992), and Cogswell (2000) suggested that the total Bay Area wintering/migrant population could be as high as 50,000 to 100,000 birds. The recent surveys of South Bay salt ponds by USGS (Takekawa et al. 2005) found eared grebe abundance highest on Alviso Ponds A8 and A11-A17.

American coots and, in much lower abundance, common moorhens breed in freshwater wetlands, channels, and ponds in and around emergent vegetation in a number of locations throughout the South Bay. These birds are omnivorous, eating a wide variety of plant and animal (particularly invertebrate) material. Coot populations are augmented substantially during winter, when this species occurs by the hundreds or low thousands on lower-salinity salt ponds (Anderson 1970), sewage treatment plant ponds, and other open-water locations.

The status of the California clapper rail and California black rail in the South Bay is described in detail in the Special-Status Wildlife Species section below (Section 3.7). Two other rails occur regularly in the South Bay. Both the sora (*Porzana carolina*) and Virginia rail (*Rallus limicola*) may breed in very small numbers in freshwater wetlands around the South Bay, although they occur much more commonly as nonbreeders from August to May. During the nonbreeding season, these secretive species occur in a wide variety of tidal and nontidal salt, brackish, and freshwater marsh habitats, being most abundant in freshwater and brackish areas. Here, these species forage primarily on invertebrates. Significant depredation of these rails by egrets and herons has been observed during exceptionally high tides in winter, particularly in areas where high tide refugia (such as upland transitional zones in the high marsh or along tidal channels) are lacking.

Terrestrial/Riparian Birds. Although riparian habitats in the Study Area have been highly degraded by vegetation removal, stream channelization, and encroachment by agriculture and urbanization, the riparian habitats within the Study Area still support high abundance and diversity of terrestrial birds. In particular, the remnant mature riparian woodland along lower Coyote Creek, augmented by the habitat restoration efforts of the Santa Clara Valley Water District, provides important breeding and foraging habitat for birds. These bird communities are dominated by insectivorous passerines during summer; representative breeding species include permanent residents such as the song sparrow, saltmarsh common yellowthroat, bushtit, chestnut-backed chickadee (*Poecile rufescens*), downy woodpecker (*Picoides pubescens*), and Anna's hummingbird and summer residents such as the California yellow warbler (*Dendroica petechia brewsteri*), Pacific-slope flycatcher (*Empidonax difficilis*), and black-chinned hummingbird (*Archilochus alexandri*). Breeding raptors include the red-tailed hawk (*Buteo jamaicensis*), red-shouldered hawk (*Buteo lineatus*), Cooper's hawk (*Accipiter cooperii*), and American kestrel (*Falco sparverius*). During spring and fall migration, large numbers of insectivores such as the Swainson's thrush, orange-crowned warbler, Wilson's warbler (*Wilsonia pusilla*), and warbling vireo (*Vireo gilvus*), forage in the riparian trees and shrubs. Seed-eating birds that frequent more open habitats during migration and winter include the white-crowned sparrow, golden-crowned sparrow, Lincoln's sparrow (*Melospiza lincolnii*), and fox sparrow (*Passerella iliaca*), in addition to resident American goldfinch (*Carduelis tristis*) and house finch. The Coyote Creek Field Station of the SFBBO (formerly Coyote Creek Riparian Station) monitors numbers of birds along lower Coyote Creek.

The lower Guadalupe River has fairly well-developed woody riparian habitat in some areas, and supports extensive emergent and ruderal vegetation that provides cover and food for high densities of a few species such as sparrows, red-winged blackbirds, and saltmarsh common yellowthroats. Riparian bird communities are more poorly developed (i.e., supporting fewer taxa and generally lower densities) along

other streams within the Study Area due primarily to degradation (or absence) of woody riparian habitat and encroachment of urbanization. For example, the portions of Calabazas, San Tomas Aquinas, Stevens, Matadero, and many other creeks in the Study Area are highly channelized, narrow corridors that support little woody riparian vegetation. Birds present in these areas are generally common stream-associated birds such as the mallard, green heron, and killdeer or common, widespread terrestrial bird, with few riparian-associated passerines.

Only a few passerines breed at all commonly in tidal salt, brackish, and freshwater marsh in the South Bay. Within most tidal salt marsh, the only nesting passerines are the Alameda song sparrow and marsh wren (in the lower marsh dominated by cordgrass and gumplant) and the savannah sparrow, which nests in pickleweed and peripheral halophytes in the upper portions of tidal and diked saltmarsh, along vegetated levees, and in adjacent upland transitional zones. South Bay population estimates for these species in 1971 by Gill (1977) included 1000-1200 pairs of marsh wrens (in cordgrass, but more abundantly in freshwater marshes, especially at Alviso and Guadalupe Sloughs, Coyote Creek and Mud Slough, and the Palo Alto Flood Control Basin), 800-1000 pairs of savannah sparrows, and 1800 pairs of Alameda song sparrows. The saltmarsh common yellowthroat may also nest in South Bay salt marshes in small numbers (Ray 1919; Steve Rottenborn, pers. obs.), although it nests primarily in brackish and freshwater marsh; this species, and the Alameda song sparrow, are discussed in detail in the Special-Status Wildlife Species section below (Section 3.7). Northern harriers, and formerly (or rarely) the short-eared owl (*Asio flammeus*), also nest within tidal salt marshes in broad vegetated marsh plains; these species are also discussed in the Special-Status Wildlife Species section (Section 3.7).

In addition, the red-winged blackbird nests in freshwater marsh in the Study Area, and scattered small trees and shrubs along salt pond levees and upland edges provide nesting sites for white-tailed kites, loggerhead shrikes, California towhees, and other species in limited numbers. Barn and cliff swallows breeding on artificial structures within and adjacent to the baylands forage commonly for flying insects over marshes and salt ponds in the South Bay.

Transmission towers within the marshes and salt ponds in the South Bay provide nesting sites for red-tailed hawks, common ravens, and peregrine falcons. Both species may prey on small mammals, rails, waterfowl, and shorebirds in the South Bay, and common ravens are particularly notorious predators of eggs and young of a variety of birds. Populations of ravens and American crows have increased markedly in recent decades throughout the Bay area, feeding heavily at the landfills around the South Bay but also preying on other wildlife species. Few data are available on the impact of ravens and crows on breeding populations of other species, but it is likely that ravens nesting on towers within tidal marshes and salt ponds have at least some impact on populations of California clapper rails, snowy plovers, and other breeding bird species.

During the nonbreeding season, additional landbirds occur in the baylands, including large numbers of sparrows of several species and several raptors. Short-eared owls occur regularly in small numbers in the more extensive marshes in winter, foraging on small mammals and birds, and merlins (*Falco columbarius*), peregrine falcons (*Falco peregrinus*), and other raptors forage for waterfowl and shorebirds throughout the South Bay.

Other upland habitats include grasslands and developed settings. Non-native grasslands in the South Bay support limited and declining populations of burrowing owl. A variety of birds use annual grasslands as foraging habitat, including savannah sparrows, horned larks (*Eremophila alpestris actia*), American pipits, western meadowlarks (*Sturnella neglecta*), lesser goldfinches, barn swallows, and various raptors. Western meadowlarks and mourning doves may nest in this habitat as well. Birds in developed areas face not only regular human disturbance, but also unique foraging and nesting opportunities. Those that are well adapted to such habitats commonly breed here. These species include the house finch, mourning dove, barn swallow, cliff swallow, and black phoebe and non-native European starling, rock pigeon (*Columba livia*), and house sparrow (*Passer domesticus*).

4.3.6 Notable Wildlife Resources in the Shoreline Study Area

Based on recent monitoring conducted by the USGS, SFBBO, and others, the most prominent wildlife resources and patterns of wildlife distribution in the Shoreline Study Area are as follows:

- Mixed heronries are located along Guadalupe Slough and at the west end of the Coyote Creek Lagoon near Newby Island, and small numbers of great blue herons nest on transmission towers in or adjacent to several salt ponds in this complex.
- Breeding concentrations of black-necked stilts and American avocets occur in New Chicago Marsh, in the vicinity of Pond A22, in Pond A8, and in the Palo Alto Flood Control Basin, with additional concentrations of avocets at the Warm Springs Marsh and Reach 1A waterbird pond, and stilts in the San Jose-Santa Clara WPCP.
- Moderate numbers of western snowy plovers breed in Pond A22 and Pond A8. In the past, western snowy plovers have bred in Pond A6, although they have not nested in this pond years, likely due to the gull colony there. Western snowy plovers have also recently nested in a small impoundment north of the Alviso marina.
- Large numbers of shorebirds forage on the intertidal mudflats ringing the South Bay south of the Dumbarton Bridge during low tide.
- Large numbers of shorebirds roost, and forage to varying degrees, in Ponds AB2, A5, and A7, with high numbers also present in Ponds A3N, A6, A9, A14, and A8, in New Chicago Marsh, in Crittenden Marsh, and at the San Jose-Santa Clara Water Pollution Control Plant at times.
- Several California gull colonies, including the state's second largest colony in Pond A6, are present in the Alviso pond complex.
- Double-crested cormorants nest on transmission towers in Pond A2W, in the AB1/AB2/A3N area, and in Pond A18, and on the levee between Ponds A9 and A10.
- Red-tailed hawks and common ravens nest on transmission towers in several ponds, and in 2007 two pairs of peregrine falcons nested in old raven nests on towers in the Alviso Complex.
- Forster's terns nest on small islands in a number of locations (primarily in salt ponds), and black skimmers nest in the Palo Alto Flood Control Basin and in Ponds A1, AB1, AB2, A8, and A16. Caspian terns nest, or have recently nested, in Pond A7, and on the levee between Ponds A5 and A7.

- The main post-breeding staging area for California least terns is within the Alviso pond complex, primarily in the ponds north of Moffett Field but with birds regularly using a number of other ponds in this pond complex for foraging and roosting. California least terns also forage over the Bay off the Alviso salt ponds.
- California clapper rails occur in a number of locations, although high-quality habitat is limited. The highest numbers are likely in the more extensive tidal salt marshes along Coyote Creek and near Palo Alto, although this species is also present in brackish marshes in the Warm Springs area, along Guadalupe Slough and Alviso Slough, and in smaller marsh remnants along sloughs and the Bay edge.
- Ponds A1, A2E, A2W, A5, A7, A9, and AB2 support high numbers of dabbling ducks, whereas Ponds A1, A2W, A9, and A10 support large numbers of diving ducks.
- Tens of thousands of gulls roost in the Alviso ponds and levees, with many foraging at landfills near Milpitas and in Fremont.
- Within the Alviso pond complex, piscivorous bird abundance is highest in Ponds A1, A2W, A3W, A5, A7, A9, A10, and AB2.
- Ponds A19, A20, and A21 have been restored to tidal action under the ISP. These ponds initially provide intertidal foraging habitat for shorebirds and other waterbirds at low tide, and tidal foraging habitat for waterfowl at high tide. As sediment accumulates (and the gypsum layer is buried and/or deteriorates), tidal marsh vegetation will become established, providing breeding and foraging habitat for the California clapper rail and other marsh species.
- Steelhead occur in San Francisquito Creek, Stevens Creek, the Guadalupe River, and Coyote Creek.
- Chinook salmon occur in the Guadalupe River and Coyote Creek.
- Salt marsh harvest mouse habitat in the Alviso pond complex is limited. Most of the marshes are brackish marshes, areas that are little used by salt marsh-dependent species such as the salt marsh harvest mouse and salt marsh wandering shrew, and the salt marsh that does exist has little to no high marsh or escape cover.
- A small population of western pond turtles (*Emys marmorata*) is present along the northern edge of Moffett Field and the Sunnyvale WPCP, with a few individuals present along the lower Guadalupe River and Coyote Creek as well.
- The Warm Springs portion of the SFBNWR supports vernal pool tadpole shrimp (*Lepidurus packardii*) and California tiger salamanders.
- Burrowing owls occur in grassland habitats fringing the South Bay, with higher concentrations at Shoreline Park, Moffett Field, and the San Jose WPCP buffer lands.
- The riparian corridor of Coyote Creek supports a variety of migrant and resident landbirds.

4.4 Special-Status Wildlife Species

Special-status animal species that occur in the Study Area and adjacent habitats are described below. The legal status and likelihood of occurrence of these species are given in Table 7. Expanded descriptions are included for species for which potentially suitable habitat occurs in the Study Area, or for which the resource agencies have expressed particular concern.

A number of special-status species occur in the Study Area as visitors, migrants, or foragers, but are not known or expected to breed in the immediate area. Expanded species accounts are not provided for these species. Animals that occasionally occur within the Study Area and breed in upland habitats in the greater South Bay Area, but occur only in the Study Area as uncommon to rare foragers, include the bald eagle (*Haliaeetus leucocephalus*), golden eagle (*Aquila chrysaetos*), Vaux's swift (*Chaetura vauxi*), bank swallow (*Riparia riparia*), yellow-breasted chat (*Icteria virens*), and pallid bat (*Antrozous pallidus*). Species that occur in the Study Area regularly as foragers, but have special status only at nesting sites elsewhere in California, include the common loon (*Gavia immer*), American white pelican, sharp-shinned hawk (*Accipiter striatus*), osprey (*Pandion haliaetus*), Barrow's goldeneye (*Bucephala islandica*), long-billed curlew, and elegant tern.

Expanded species accounts are provided below for key special-status wildlife species. More information on most of these species can be found in the Goals Project Baylands Ecosystem Species and Community Profiles (Goals Project 2000).

Table 7 – Special-status animal species, their status, and potential occurrence in the Shoreline Study Area.

Name	Status*	Habitat	Potential For Occurrence On Site
Federal or State Threatened or Endangered Species			
Bald Eagle (<i>Haliaeetus leucocephalus</i>)	FPD, SE, SP	Occurs mainly along seacoasts, rivers and lakes; nests in tall trees or in cliffs. Feeds mostly on fish.	Occasional visitor, primarily during winter, to the Study Area. May occasionally forage, but does not nest, in the Study Area.
American Peregrine Falcon (<i>Falco peregrinus anatum</i>)	SE, SP	Forages in many habitats; nests on cliffs and similar human-made structures.	Regular forager (on other birds) in the Study Area, primarily during migration and winter. Nested in 2006 and 2007 (two nests) in old raven nests on transmission towers in the Alviso pond complex.
California Clapper Rail (<i>Rallus longirostris obsoletus</i>)	FE, SE, SP	Salt and brackish marsh habitat usually dominated by pickleweed and cordgrass.	Resident in many tidal marshes in the Study Area.
California Least Tern (<i>Sterna antillarum browni</i>)	FE, SE, SP	Nests along the coast on bare or sparsely vegetated flat substrates.	The South Bay is an important post-breeding staging area for least terns, although this species does not currently breed within the Study Area. Recent breeding by small numbers has occurred at Hayward Regional Shoreline and Eden Landing Pond E8A. Forages and roosts in a number of South Bay ponds, especially Alviso ponds in the vicinity of Moffett Field.
California Brown Pelican (<i>Pelecanus occidentalis californicus</i>)	FE, SE, SP	Occurs in nearshore marine habitats and coastal bays. Nests on islands in Mexico and southern California.	Regular during nonbreeding season (summer and fall) in Study Area. Roosts on levees in the interiors of pond complexes, forages in salt ponds and Bay.
Salt Marsh Harvest Mouse (<i>Reithrodontomys raviventris</i>)	FE, SE, SP	Salt marsh habitat dominated by pickleweed.	Occurs in pickleweed marshes within the Study Area. Also occurs in brackish marshes.
Steelhead – California Central Coast ESU (<i>Oncorhynchus mykiss</i>)	FT	Cool streams with suitable spawning habitat and conditions allowing migration, as well as marine habitats.	Known to be present in several South Bay creeks (including Coyote, Stevens, and San Francisquito Creeks, and the Guadalupe River) and associated marshes and small channels in the Study Area, especially as habitat for smolts as they transition to life in a marine environment. Suitable spawning habitat is not present in the Study Area, but this species moves through the area to spawn upstream.
California Black Rail (<i>Laterallus jamaicensis coturniculus</i>)	ST, SP	Breeds in fresh, brackish, and tidal salt marsh.	Non-breeding individuals winter in small numbers in tidal marsh within the Study Area, but the species is not currently known to breed in the South Bay.
Western Snowy Plover (<i>Charadrius alexandrinus nivosus</i>)	FT, CSSC	Nests on sandy beaches and salt panne habitats.	Breeds and forages at several sites within the Study Area, primarily Ponds A8 and A23. Additional birds occur in the Study Area during winter.
Bank Swallow (<i>Riparia riparia</i>)	ST	Colonial nester on vertical banks or cliffs with fine-textured soils near water.	Observed in the study area as rare transient. No suitable breeding habitat in the Study Area.

Name	Status*	Habitat	Potential For Occurrence On Site
California Tiger Salamander (<i>Ambystoma californiense</i>)	FT, CSSC	Vernal or temporary pools in annual grasslands, or open stages of woodlands.	A population is present on SFBNWR lands in the Fremont/Warm Springs area within the Study Area.
Vernal Pool Tadpole Shrimp (<i>Lepidurus packardii</i>)	FE	Freshwater vernal pools in grasslands.	Present in small numbers in vernal pools on SFBNWR lands in the Fremont/Warm Springs area.
California Species of Special Concern			
Central Valley Fall- and Late Fall-run Chinook Salmon (<i>Oncorhynchus tshawytscha</i>)	CSSC (Late Fall-run only)	Cool rivers and large streams that reach the ocean and that have shallow, partly shaded pools, riffles, and runs.	Central Valley Fall-Run Chinook salmon are known to be present in several South Bay creeks (including Coyote Creek, Alameda Creek, and the Guadalupe River) and associated marshes and small channels in the Study Area, especially as habitat for smolts as they transition to life in a marine environment. Suitable spawning habitat is not present in the Study Area, but this species moves through the area to spawn upstream.
Western Pond Turtle (<i>Clemmys marmorata</i>)	CSSC	Permanent or nearly permanent fresh or brackish water in a variety of habitats.	Uncommon along the inshore side of pond A3W; a few are occasionally recorded along lower Coyote Creek and the Guadalupe River. May occur rarely in freshwater and brackish creeks and sloughs elsewhere in the Study Area.
Common Loon (<i>Gavia immer</i>)	CSSC (nesting)	Nests in freshwater marshes, winters in coastal marine habitats.	Occasional winter visitor; does not breed in the Study Area.
American White Pelican (<i>Pelecanus erythrorhynchos</i>)	CSSC (nesting)	Forages in freshwater lakes and rivers, nests on islands in lakes.	Common non-breeder, foraging primarily on salt ponds in the Study Area. Regular visitor from late summer to spring. Not known to breed in the Study Area.
Double-crested Cormorant (<i>Phalacrocorax auritus</i>)	CSSC (nesting)	Colonial nester on coastal cliffs, offshore islands, electrical transmission towers, and along interior lake margins. Feeds on fish.	Breeds on electrical transmission towers and on levees within the Study Area, and forages in ponds and other open water habitats in the Study Area.
White-faced Ibis (<i>Plegadis chihi</i>)	CSSC (nesting)	Forages in freshwater marshes, and to a lesser extent, brackish areas.	Occasional visitor in fall and winter. Has bred in heron rookery on Mallard Slough, but no current nesting known.
Barrow's Goldeneye (<i>Bucephala islandica</i>)	CSSC (nesting)	Nests in freshwater marshes, winters in coastal marine habitats.	Occasional winter visitor; does not breed in the Study Area.
Northern Harrier (<i>Circus cyaneus</i>)	CSSC (nesting)	Nests and forages in marshes, grasslands, and ruderal habitats.	Breeds in small numbers in marsh habitats in the Study Area, forages in a variety of habitats.
Sharp-shinned Hawk (<i>Accipiter striatus</i>)	CSSC (nesting)	Nests in woodlands, forages in many habitats in winter and migration.	Observed on site as a migrant and winter resident. No breeding habitat in Study Area.
Cooper's Hawk (<i>Accipiter cooperii</i>)	CSSC (nesting)	Nests in woodlands, forages in many habitats in winter and migration.	Breeds in limited numbers in upland habitats fringing the South Bay; forages throughout the Study Area.

Name	Status*	Habitat	Potential For Occurrence On Site
Osprey (<i>Pandion haliaetus</i>)	CSSC (nesting)	Nests in tall trees or cliffs on freshwater lakes and rivers and along seacoast; feeds on fish.	Occasional forager, primarily during the nonbreeding season. No breeding records in the Study Area.
Golden Eagle (<i>Aquila chrysaetos</i>)	CSSC	Breeds on cliffs or in large trees or electrical towers, forages in open areas.	Occasional forager, primarily during the nonbreeding season. No nesting records within the Study Area.
Merlin (<i>Falco columbarius</i>)	CSSC	Uses many habitats in winter and migration.	Regular in low numbers during migration and winter. Does not nest in California.
Long-billed Curlew (<i>Numenius americanus</i>)	CSSC (nesting)	Nests on prairies and short-grass fields; forages on mudflats, marshes, pastures, and agricultural fields.	Forages on mudflats, marshes, and grasslands and roosts on levees, diked marshes, and ponds within the Study Area as a migrant and winter resident. Does not nest in the Study Area.
California Gull (<i>Larus californicus</i>)	CSSC (nesting)	Nests on lakes inland and, around S. F. Bay, in salt ponds.	Common resident, breeding on several salt ponds in the Study Area. The colony in Pond A6 is the second largest colony in California. Forages throughout Study Area.
Black Skimmer (<i>Rynchops niger</i>)	CSSC (nesting)	Nests on abandoned levees and islands in salt ponds and marshes.	A few pairs breed and forage in the Study Area, on islands in salt ponds.
Short-eared Owl (<i>Asio flammeus</i>)	CSSC (nesting)	Nests on ground in tall emergent vegetation or grasses, forages over a variety of open habitats.	Uncommon. Has bred in small numbers within the Study Area, although current breeding status unknown. Most numerous in area in migration and winter.
Western Burrowing Owl (<i>Athene cunicularia hypugea</i>)	CSSC	Flat grasslands and ruderal habitats.	Breeds at several upland sites within the Study Area.
Vaux's Swift (<i>Chaetura vauxi</i>)	CSSC (nesting)	Nests in snags in coastal coniferous forests or, occasionally, in chimneys; forages aerially.	Forages over Study Area. No nesting habitat within area.
Loggerhead Shrike (<i>Lanius ludovicianus</i>)	CSSC (nesting)	Nests in dense shrubs and trees, forages in grasslands, marshes, and ruderal habitats.	Resident in low numbers within the Study Area.
California Horned Lark (<i>Eremophila alpestris actia</i>)	CSSC	Short-grass prairie, annual grasslands, coastal plains, and open fields.	Present in low numbers in the Study Area, nesting on salt pond levees, salt flats, and ruderal habitats.
California Yellow Warbler (<i>Dendroica petechia brewsteri</i>)	CSSC (nesting)	Breeds in riparian woodlands, particularly those dominated by willows and cottonwoods.	Nests in riparian corridor of Coyote Creek.
Saltmarsh Common Yellowthroat (<i>Geothlypis trichas sinuosa</i>)	CSSC	Breeds primarily in fresh and brackish marshes in tall grass, tules, willows; uses salt marshes more in winter.	Common resident, breeding in freshwater and brackish marshes (and possibly to a limited extent in salt marshes), and foraging in all marsh types during the nonbreeding season.
Yellow-breasted Chat (<i>Icteria virens</i>)	CSSC	Riparian brush and woodlands.	Rare nonbreeding visitor to riparian habitats during migration.

Name	Status*	Habitat	Potential For Occurrence On Site
Alameda Song Sparrow (<i>Melospiza melodia pusillula</i>)	CSSC	Breeds in salt marsh, primarily in marsh gumplant and cordgrass along channels.	Uncommon resident, breeding and foraging in tidal salt marsh.
Tricolored Blackbird (<i>Agelaius tricolor</i>)	CSSC (nesting)	Breeds near fresh water in dense emergent vegetation.	Has bred in the Study Area at the San Jose-Santa Clara Water Pollution Control Plant, but occurs in the Study Area primarily as a nonbreeding forager.
Salt Marsh Wandering Shrew (<i>Sorex vagrans halicoetes</i>)	CSSC	Medium high marsh with abundant driftwood and pickleweed.	May occur in salt marshes throughout the Study Area, although numbers have declined, and current status is unknown.
State Protected Species or CNPS Species			
White-tailed Kite (<i>Elanus caeruleus</i>)	SP (nesting)	Nests in tall shrubs and trees, forages in grasslands, marshes, and ruderal habitats.	Common resident; breeds within the Study Area where suitable nesting habitat occurs.

FE = Federally-listed Endangered
 FT = Federally-listed Threatened
 FPD = Federally Proposed for Delisting
 SE = State-listed Endangered
 ST = State-listed Threatened
 CSSC = California Species of Special Concern
 SP = State Fully Protected Species

4.4.1 Federal or State Threatened or Endangered Species

Vernal Pool Tadpole Shrimp (*Lepidurus packardii*). Federal Listing Status: Endangered; State Listing Status: None. The vernal pool tadpole shrimp is a small crustacean that occurs in ephemeral pools in California. The known range of the species is limited to the Central Valley, and a limited area in, and adjacent to, the Warm Springs Seasonal Wetland Unit of the SFBNWR. Due to the continuing loss of habitat, the vernal pool tadpole shrimp was listed by the USFWS as Endangered in 1994. Critical habitat was designated for the species in 2006 (USFWS 2006a); the Study Area includes two Critical Habitat Units, 14A and 14B, within the Warm Springs Seasonal Wetland Unit of the SFBNWR.

Vernal pool tadpole shrimp spend the majority of their lives as dormant cysts, which may remain viable for up to ten years. When these cysts are inundated in vernal pools, some hatch into shrimp, which live only as long as the pool retains water. Ahl (1991) found that egg cysts hatch within 11 to 26 days (mean = 17 days) after pools refill with water. In contrast to most fairy shrimp, juvenile vernal pool tadpole shrimp develop slowly and require a minimum hydroperiod of about seven to eight weeks to reach reproductive maturity in the field (Gallagher 1996, Helm 1998). Juveniles look like the adults but are merely smaller in overall size and are not reproductively mature. There is only one generation per year. Adults have hard carapaces, and may attain a length of one inch or more.

This shrimp is generally found in sparsely vegetated, grass-bottomed swales on old alluvial soils that are underlaid by hardpan, or in mud-bottomed pools containing highly turbid water. The pools are usually deep (\geq six inches) and typically retain water longer than shallower vernal pools. Unlike fairy shrimp, which actively swim in the water column, tadpole shrimp move about primarily by crawling, but will swim for brief periods. Vernal pool tadpole shrimp are not expected to occur in the Shoreline Study Area outside the area of known distribution in the mixed vernal pool/grassland habitat north/northwest of Pond A22 in the Warm Springs Seasonal Wetland Unit of the SFBNWR.

California Tiger Salamander (*Ambystoma californiense*). Federal Listing Status: Threatened; State Listing Status: Species of Special Concern. The California tiger salamander breeds in temporary (lasting at least 12 weeks) or small permanent ponds in grassland habitats during the winter rainy season. During dry summer months, they aestivate in small mammal burrows in grasslands adjacent to breeding ponds. Adults often emerge from the burrows at night during the first moderate to heavy winter rains and migrate to breeding ponds where they lay their eggs.

The eggs are attached singly or in small clumps to vegetation under water, or directly on the bottom of the pool if emergent vegetation is lacking. The eggs hatch approximately one week after they are deposited. The larvae prey upon invertebrates and other amphibian larvae for between three and six months, during which time they metamorphose into juveniles. Juveniles typically leave the pools in mass during a one to two week period, usually as the ponds dry. The juveniles then search for available burrows. Juveniles feed and grow in these burrows until the following winter. California tiger salamanders take several years to reach maturity and do not necessarily breed every year, even if sufficient habitat is available.

The range of the California tiger salamander is restricted to the Central Valley and the South Coast Range of California from Butte County south to Santa Barbara County. Tiger salamanders have disappeared from a significant portion of their range due to habitat loss from agriculture and urbanization and the introduction of non-native aquatic predators. The California tiger salamander was listed as Threatened under the FESA by the USFWS in July 2004. The USFWS designated Critical Habitat for the California tiger salamander in August 2005 (USFWS 2005). No portion of the Study Area is within Critical Habitat for this species.

California tiger salamanders occur in the mixed vernal pool/grassland habitat north/northwest of Pond A22 in the Warm Springs Seasonal Wetland Unit of the SFBNWR, the only location in the South Bay that they occur adjacent to tidally influenced marsh habitat.

Steelhead (*Oncorhynchus mykiss*), Central California Coast ESU. Federal Listing Status: Threatened; State Listing Status: None. The steelhead is an anadromous form of rainbow trout that migrates upstream from the ocean to spawn. Steelhead in the South Bay usually migrate upstream to spawning areas from late December through early April, with the greatest activity in January through March, when flows are sufficient to allow them to reach suitable habitat in far upstream areas. Spawning occurs between December and June. Steelhead eggs remain in gravel depressions, known as redds, for 1.5 to four months before hatching. After hatching, young-of-the-year steelhead tend to use riffles with cover, while older juveniles use deeper water (such as pools) as rearing habitat, remaining in fresh water for one to four years before migrating to the ocean. This downstream migration of juveniles generally occurs between February and June. After migration, steelhead typically grow rapidly for two to three years before returning to freshwater streams to spawn. Unlike other anadromous salmonids, steelhead do not necessarily die after spawning. Adults may survive and return to the ocean after spawning, coming back to spawn for one or more additional seasons; however, it is unknown if this phenomenon occurs in the South Bay streams.

Steelhead usually spawn in gravel substrates in clear, cool, perennial sections of relatively undisturbed streams. Preferred streams typically support dense canopy cover that provides shade, woody debris, and organic matter, and are usually free of rooted or aquatic vegetation. Steelhead usually cannot survive long in pools or streams with water temperatures above 70 °F, but they can use warmer habitats if food is available, such as at fast water riffles where fish can feed on drifting insects. Steelhead in some coastal estuaries in central California apparently make extensive use of estuarine habitats for foraging (Bush, pers. comm.), although the extent of the use of estuarine habitats by steelhead in many areas, including the South San Francisco Bay area, is virtually unknown.

Steelhead populations in many areas have declined due to degradation of spawning habitat, introduction of barriers to upstream migration, over-harvesting by recreational fisheries, and reduction in winter flows due to damming and spring flows due to water diversion. Steelhead and other salmonids have been categorized into subpopulations, or Distinct Population Segments (DPSs). In 1997, the National Marine Fisheries Service (NMFS) listed the Central California Coast DPS as a threatened species under FESA; threatened status was reaffirmed in 2006. The Central Coast DPS includes all runs from the Russian

River in Sonoma County south to Aptos Creek in Santa Cruz County, including all steelhead spawning in streams flowing into San Francisco Bay streams. In 2005, NMFS designated critical habitat for this and other DPSs as occupied reaches of all rivers and estuaries within the range of each listed DPS. A recovery plan is being developed but has not yet been approved for this DPS.

Steelhead are known to occur in several stream systems in the South San Francisco Bay Area (Figure 5), and this species could potentially spawn in virtually any reach of a stream offering suitable spawning habitat and lacking downstream barriers to dispersal. Information on the fine-scale distribution of steelhead in South San Francisco Bay streams is limited, but steelhead are currently known to run in the Coyote Creek, Guadalupe River, Stevens Creek, and San Francisquito Creek watersheds (Foxgrover et al. 2004, Leidy et al. 2005). Few steelhead are present in any of these South Bay streams (Leidy et al. 2005). Within the Study Area, no suitable steelhead spawning habitat exists. Steelhead may use tidal channels in marshes as well, as such channels (particularly in brackish marshes) may provide habitat for juveniles during the process of smoltification (i.e., physiological adaptation to the saltwater environment). The use of larger sloughs within the Study Area by juvenile salmonids may be limited by the relatively high density of predators, including harbor seals and striped bass (Jerry Smith, pers. comm.).

Chinook Salmon (*Oncorhynchus tshawytscha*), Central Valley Fall- and Late Fall- Run ESU. Federal Listing Status: None; State Listing Status: Species of Special Concern (Late Fall-Run only). Like the steelhead, the Chinook salmon is an anadromous salmonid. Adults of the Central Valley Fall-Run ESU migrate from the ocean to spawning streams in fall and begin spawning in beds of coarse river gravels between September and December. Adults die after spawning. After the eggs hatch, juvenile salmon typically migrate downstream to the Bay or ocean within a few months. Young fish remain in the ocean for several years before returning to freshwater streams and rivers to spawn. Chinook salmon generally spawn in cool waters providing incubation temperatures no warmer than 55 °F.

Much more is known regarding the use of estuarine habitats by Chinook salmon than steelhead, and in at least some areas, juvenile Chinook make heavy use of estuarine habitats. Juvenile Chinook salmon may spend a significant amount of time, up to 189 days (Simenstad et al. 1982), foraging in estuarine habitats, showing significant growth in some estuaries (MacDonald et al. 1987), as they adapt physiologically to higher-salinity environments (Maragni 2000). In at least some areas, tidal marshes are important habitats for Chinook salmon. Fry forage throughout shallower tidal sloughs and channels, even foraging within the marsh during flood tides, while larger smolts forage in larger primary and secondary channels and subtidal habitats (Maragni 2000).

Fall-run Chinook salmon populations have suffered the effects of over-fishing by commercial fisheries, degradation of spawning habitat, added barriers to upstream migration, and reductions in winter flows due to damming. Approximately 40-50% of the spawning and rearing habitats in Central Valley streams have been lost or degraded. Hatchery-raised fish considerably enhance present populations. Because long-term population trends have been generally stable, NMFS determined that the Central Valley fall- and late fall-run evolutionarily significant unit (ESU) was not a priority for listing as threatened or endangered.

Chinook salmon did not historically spawn in streams flowing into South San Francisco Bay. Since the mid-1980s, however, small numbers of fall-run Chinook salmon have been found in several such streams, including Coyote Creek, Los Gatos Creek, and the Guadalupe River (Leidy et al. 2003). Genetic analysis indicates that fish from Guadalupe River and Coyote Creek are closely related to Central Valley Fall-run Chinook salmon (Garcia-Rossi and Hedgecock 2002).

These fall-run Chinook salmon typically arrive in South San Francisco Bay streams in October or later, although on rare occasions, adult Chinook salmon have been detected in these streams in summer, and spawning has been observed on Los Gatos Creek as early as September (Salsbery, pers. comm.). Seasonal stream flow and temperature conditions in these streams may not be suitable for successful spawning by Sacramento River winter-run Chinook salmon, which typically spawn in late spring and summer, or by Central Valley spring-run Chinook salmon, which typically spawn in late summer and early fall. Therefore, any adult Chinook salmon found in the South San Francisco Bay in the summer are presumed to be Fall-run fish with ancestry to the Central Valley. The use of tidal channels and sloughs within the Study Area by Chinook salmon is unknown. Predation pressure may limit the use of larger sloughs as more than transit habitat, as noted above for steelhead, but it is possible that Chinook salmon use tidal marshes in the South Bay as extensively as has been reported in other areas.

California Brown Pelican (*Pelecanus occidentalis californicus*). Federal Status: Endangered; State Status: Endangered. Brown pelicans are large seabirds found in coastal and nearshore marine habitats along the Atlantic, Gulf and Pacific coasts of North America. In the middle of the 20th century, brown pelican populations were severely reduced. The primary cause of this decline was eggshell thinning related to ingestion of the pesticide DDT, which entered the marine food chain through agricultural runoff and industrial discharge (Anderson and Gress 1983). The brown pelican was listed by the USFWS as Endangered in 1970 and by the state of California in 1971, and the state considers it a fully protected species. A recovery plan for the species was completed in 1983 (U.S. Fish and Wildlife Service 1983); critical habitat has not been designated for the brown pelican. DDT was banned in the United States in 1972, and brown pelican populations began recovering. In 1985, the brown pelican was delisted in the southeastern U.S. as recovered, but west coast populations did not recover as quickly (Shields 2002). However, west coast numbers have increased substantially in the past two decades, and the U.S. Fish and Wildlife Service is considering a proposal to delist the California brown pelican (USFWS 2006b).

The California brown pelican nests in Mexico, on the California Channel Islands, and at the Salton Sea in early spring, approximately January to May (Anderson and Gress 1983; Shields 2002). Much of the postbreeding dispersal occurs northward (as far north as Canada), and by June, many post-breeding birds are present in central California. Local abundance in central California usually peaks from August to October (Briggs et al. 1987; Jaques 1994). Although a small number of non-breeding birds may be found locally year-round, most pelicans return to their southern breeding grounds by January. California brown pelicans feed on northern anchovies and other small fishes, which they capture by plunge-diving. Brown pelicans require secure night-roosts, free of terrestrial predators (Jaques 1994).

Several hundred brown pelicans typically occur in San Francisco Bay during summer and fall, but numbers are variable (Ainley 2000a). Post-breeding dispersants typically begin to arrive in the South Bay

in June and July, with most individuals departing by late fall. However, a few may also be found in the South Bay in winter and spring as well (Santa Clara County Bird Data Unpublished). California brown pelicans occur regularly in some South Bay salt ponds, and often roost on salt pond levees. Recent surveys by USGS included 225 individuals in the Alviso Complex in September 2004, although more typical counts number less than 100 at Alviso Ponds (Takekawa et al. 2005). Several ponds in the Alviso Complex are used for roosting by brown pelicans, with the greatest use in the vicinity of Alviso Slough and Guadalupe Slough (Takekawa et al. 2005), although local concentrations may occur in any of the lower-salinity ponds (which provide fish) throughout the Alviso Complex. Although information on daily activity patterns, habitat use, and key foraging areas of brown pelicans in the South Bay is limited, this species uses salt ponds both for foraging (which takes place in the less saline ponds supporting fish) and for roosting (on levees between ponds).

American Peregrine Falcon (*Falco peregrinus anatum*). Federal Listing Status: Delisted; State Listing Status: Endangered, Fully Protected. The peregrine falcon occurs throughout much of the world, and is known as one of the fastest flying birds of prey. Peregrine falcons prey almost entirely on birds, which they kill while in flight. These falcons nest on ledges and caves on steep cliffs, as well as human-made structures like buildings and power towers. In California, they are known to nest along the entire coastline, the northern Coast, and the Cascade Ranges and Sierra Nevada. During winter and migration, this species can be found throughout the state. Peregrine falcons are most likely to be encountered in coastal or inland marsh habitats where large numbers of waterfowl and shorebirds concentrate, as occurs at the Study Area.

A severe decline in populations of the widespread North American subspecies *Falco peregrinus anatum* began in the late 1940s. This decline was attributed the accumulation of DDE, a metabolite of the organochlorine pesticide DDT, in aquatic food chains (Thelander and M. 1994). When concentrated in the bodies of predatory birds such as the peregrine falcon, Bald Eagle, brown pelican, and Osprey, this contaminant led to reproductive effects, such as the thinning of eggshells. The American peregrine falcon was listed as Endangered by the USFWS in 1970 and by the State of California in 1971. Recovery efforts included the banning of DDT in North America and captive breeding programs. The USFWS removed the American peregrine falcon from the Endangered Species List in 1999, though the State of California still lists the species as endangered, and as a fully protected species.

Peregrine falcons are uncommon in the Study Area, but nonbreeders are present in small numbers in fall and winter. These birds often use electrical transmission towers as perches, hunting waterbirds over salt ponds, marshes, and the open bay. Prior to 2006, this species was not known to breed in the Study Area. However, in 2006 a pair nested in an old raven nest on a transmission tower in the Alviso pond complex, and two nests approximately 1.3 kilometers apart were occupied in 2007.

California Clapper Rail (*Rallus longirostris obsoletus*). Federal Listing Status: Endangered; State Listing Status: Endangered. The California clapper rail is a secretive marsh bird currently endemic to the marshes of San Francisco Bay. It formerly bred at several other locations, including Humboldt Bay, Elkhorn Slough (Monterey County), and Morro Bay, but is now extirpated from all sites outside of San Francisco Bay. California clapper rails nest in salt and brackish marshes along the edge of the bay, and

are most abundant in extensive salt marshes and brackish marshes dominated by cordgrass, pickleweed, and marsh gumplant, and containing complex networks of tidal channels (Harvey 1980). Shrubby areas adjacent to or within tidal marshes are important for predator avoidance at high tides.

California clapper rails breed from February through August in the vegetation along tidal sloughs. Breeding generally occurs in two pulses, one in April/May, and a second in June/July. Clapper rails lay up to 14 eggs, which are incubated by both parents for just under a month. The young are precocial, but are dependent on their parents for food for five to six weeks (Eddleman and Conway 1998). California clapper rails are non-migratory, although juveniles disperse around the Bay during late summer and autumn. Adults are territorial, and maintain territories throughout the year. Most California clapper rails studied via radio-telemetry had home ranges of about 115 meters in radius (Keldsen 1997). They forage on crabs, clams, and other invertebrates, which they find in exposed mud along tidal channels (usually secondary channels) or in vegetation at the edges of such channels (Shuford 1993).

Since the mid-1800s, about 90% of San Francisco Bay's marshlands have been eliminated through filling, diking, or conversion to salt evaporation ponds (Goals Project 1999). As a result, the California clapper rail lost most of its former habitat, and the population declined severely. The subspecies was listed by the USFWS as Endangered in 1970, and by the State of California as Endangered in 1971, and the state considers it a fully protected species. The USFWS approved a joint recovery plan of the salt marsh harvest mouse and the California clapper rail in 1984 (U.S. Fish and Wildlife Service 1984), and an updated Tidal Marsh Species Recovery Plan is currently under development. Critical habitat has not been proposed for the California clapper rail.

In the 1970s, the Bay-wide population estimate for California clapper rails was 4000-6000 birds, with 55% in the South Bay, 38% in Napa marshes, and the remaining 8% in other North Bay and outer coast marshes (Gill 1979). Based on surveys of most suitable marshes in the San Francisco Bay area in the late 1970s and early 1980s, Harvey (1988) estimated a population of 1500 individuals. The difference between the estimates of Gill (1979) and Harvey (1988) may have reflected a population decline, but was also likely a result of more accurate surveys by Harvey. Nevertheless, density estimates in three South Bay marshes were found to decline from 1.47, 0.89, and 0.69 rails/hectare in 1980 (Harvey 1988) to 0.64, 0.26, and 0 rails/ha, respectively in 1989 (Foerster et al. 1990), indicating an actual, considerable population decline. Populations of rails in five South Bay marshes declined by as much as 85%, apparently as a result of depredation by the non-native red fox (Albertson 1995). By the mid 1980s, approximately 1200-1500 California clapper rails remained, with greater than 80% occurring in the South Bay. By 1988, populations were estimated at 700 rails, and by 1991 the bay-wide total was estimated at 300-500 individuals (Alberston and Evens. 2000).

Clapper rail predation by both red foxes and feral cats has been directly documented in the South Bay by the tracking of radio-marked rails that were depredated in 1991 and 1992 (Albertson 1995). In addition, the remains of clapper rails were found at a fox den in a tidal marsh on the SFBNWR (Harding et al. 1998), and at the entrance to a den in the outboard levee along salt pond A9 (Steve Rottenborn, pers. obs.). Norway rats are thought to be one of the main predators of California clapper rail eggs (Foerster et

al. 1990; Harvey 1988), and raccoons have also been known to prey on California clapper rail eggs (Foerster et al. 1990).

A predator management plan implemented by the SFBNWR since 1991 has met with some success in reducing the effects of mammalian predators on clapper rails, resulting in an increase in rail populations (Harding et al. 1998). Between 1991 and 1996, clapper rail population size within a given marsh showed a significant negative relationship with the number of red foxes removed the prior year, and rail population growth rates were significantly related to red fox trapping success the prior year. The most recent population estimate for California clapper rails was approximately 1040 to 1264 birds in 2000 (Alberston and Evens. 2000). Although management of mammalian predators has helped boost clapper rail populations, avian depredation by raptors, common ravens, and possibly gulls still poses a threat, and may be increasing (Alberston, pers. comm.). In 2003, the CDFG implemented a predator-control program at the Eden Landing Ecological Reserve to reduce predation on listed species (John Krause, pers. comm.).

Other ongoing threats to clapper rails include loss of habitat to sea-level rise (Keldsen 1997), human disturbance, and accumulation of mercury and other contaminants. Few data are available regarding the effects of human disturbance on California clapper rails. Clapper rails are typically shy and reclusive, and avoid areas of high human use. Construction-related disturbance has been found to result in abandonment of territories, but in one instance, use of a jack-hammer within 50 feet of a territory did not result in abandonment of that territory (Wetlands Research Associates 1994).

California clapper rail eggs collected from several sites around the San Francisco Bay in 1975, 1986, and 1987 were found to have elevated levels of PCBs, selenium, and mercury (Lonzarich et al. 1992). Analysis of unhatched eggs from the Central Bay by Schwarzbach and Adelsbach (2003) detected mean mercury concentrations of 0.81 ppm on a fresh wet weight basis, concentrations that were considered embryotoxic. The levels and effects of mercury concentrations in South Bay birds are the subjects of ongoing study.

Breeding-season surveys of South San Francisco Bay marshes for California clapper rails through the early 1990s, summarized by Foin et al. (1997), indicated that the most substantial populations of clapper rails in the South Bay were, predictably, in the largest sections of tidal salt marsh: at Mowry Marsh and Dumbarton Marsh (in the east Bay between the Dumbarton Bridge and Mowry Slough), at the Faber/Laumeister Tracts and other marshes in the Palo Alto/East Palo Alto area, and at Greco Island in Redwood City. Mean counts from these areas include 68 birds at Mowry Marsh, 57 at Faber-Laumeister, and 44 at Dumbarton (Foin et al. 1997). Nest searches by San Francisco Bay NWR personnel detected 40 nests in the Faber/Laumeister Tracts, 33 on Greco Island, and 13 in North Mowry Marsh in 1992 (Keldsen 1997). Clapper rails occurred in many other marshes as well, including Ideal Marsh (adjacent to Cargill pond N5), Calaveras Marsh (adjacent to Cargill Ponds M2 and M3), and Triangle Marsh in Alviso. Clapper rails have been found to occasionally use salt pond dredge locks as high-tide refugia (Wetlands Research Associates 1994b). Although site-specific surveys have not been conducted in all suitable habitat for clapper rails in the South Bay, this species is likely to occur in tidal salt marsh habitats in a number of additional areas as well (Figure 5).

Although California clapper rails are typically found in tidal salt marshes, they have also been documented in brackish marshes in the South Bay. Breeding-season surveys conducted in marshes bordering Coyote Creek in 1989 documented breeding California clapper rails in a wide variety of plant associations. Surveys conducted during the 1990 breeding season (H. T. Harvey & Associates 1990d) and winter season (H. T. Harvey & Associates 1990c) found a number of California clapper rails occupying salt/brackish transitional marshes and several brackish, alkali bulrush-dominated marshes, including Warm Springs Marsh (immediately east of Pond A19) and the marshes along upper Coyote Slough even farther east. In addition, California clapper rails were found in nearly pure stands of alkali bulrush along Guadalupe Slough in 1990 and 1991 (H. T. Harvey & Associates 1990c; H. T. Harvey & Associates 1990d; H. T. Harvey & Associates 1991c). Although it has been suggested that habitat quality may be lower in brackish marshes than in salt marshes (Shuford 1993), further studies comparing reproductive success in different marsh types are necessary to determine the value of brackish marshes to California clapper rails.

On rare occasions, California clapper rails have been recorded even farther upstream, in brackish/freshwater transition marshes, particularly during the nonbreeding season. In the Alviso/Sunnyvale area, such individuals have been recorded along upper Alviso Slough near the Gold Street bridge (14 February 1997; Scott B. Terrill, pers. obs.), in nontidal freshwater ponds between Calabazas and San Tomas Aquino Creeks north of Highway 237 in Sunnyvale (16 August 1998; Steve Rottenborn, pers. obs.), and along Artesian Slough near the Environmental Education Center in January 1999 and January-February 2001 (Santa Clara County Bird Data Unpublished).

No Bay-wide breeding-season surveys have been conducted for clapper rails since the 1990s. However, the USFWS, in conjunction with other agencies, conducts annual winter high-tide surveys using an airboat. These surveys attempt to cover all South Bay marshes at least once every two years (although areas with dense cordgrass cannot be surveyed with this method except on the highest tides). Recent winter surveys indicate that clapper rail populations in the Mowry/Dumbarton Slough area appear to be fluctuating, but populations in other areas seem to be more stable, see Table 8 (Alberston, pers. comm.). This may be the result of higher avian predation rates in the Mowry/Dumbarton area, but this hypothesis has not been studied.

Table 8 – High and low winter counts of clapper rails from major tidal salt marshes in the South Bay, 1994-2000 and 2002 (USFWS unpubl. data).

Location	High Count (Year)	Low Count (Year)
Dumbarton	104 (1994)	28 (2000)
Mowry	126 (1997)	4 (2000)
Hooks Island	46 (1997)	16 (2000, 2002)
Palo Alto Harbor	16 (1997)	5 (2002)
Faber	60 (1997)	29 (1995)
Laumeister	48 (1997)	24 (1995)
Greco Island	96 (2002)	87 (2000)

Both winter and breeding season surveys suggest that there is substantial annual variability in local distribution and abundance of clapper rails in the South Bay. For example, at one of the sites where rails were found in brackish marshes in Guadalupe Slough (discussed above), no rails were found during protocol-level surveys the year before (H. T. Harvey & Associates 1990c; H. T. Harvey & Associates 1990d; H. T. Harvey & Associates 1991c). Table 8 shows the high variability in winter counts, and suggests that populations may be particularly high in certain years, such as 1997, presumably following high breeding success.

California Black Rail (*Laterallus janaicensis coturniculus*). Federal Listing Status: None; State Listing Status: Threatened. The California black rail is a small rail that inhabits tidal salt, brackish, and freshwater marshes. This small bird is very secretive, and is most often seen during high tides when it is forced into high marshes. Little information is available regarding the biology of California black rails. They are most abundant in tidal marshes with some freshwater input (Evens et al. 1991). They nest primarily in pickleweed-dominated marshes with patches or borders of *Scirpus*, often near the mouths of creeks. They build nests in tall grasses or marsh vegetation during spring, and lay about six eggs. Nests are usually constructed of pickleweed, and are placed directly on the ground or slightly above ground in vegetation. Black rails feed on terrestrial insects, aquatic invertebrates, and possibly seeds (Trulio and Evens 2000).

The California black rail reportedly bred in the Alviso area in the early 1900s (Wheelock 1916), but currently it is not known to breed in the South Bay. In the San Francisco Bay area, this small rail currently breeds primarily in marshes in the north San Francisco Bay Area (i.e., San Pablo Bay and Suisun Bay). After breeding, some black rails disperse into the South Bay, accounting for most records of the species in this area. Here, the abundance of the black rail during the nonbreeding season is unknown due to its very small size and highly secretive nature. Most observations of black rails in the South Bay consist of only a few birds observed seeking high-tide refugial cover at the edges of the salt marsh in a few areas during spring tides from November to February. Nearly every winter, small numbers (up to ten or more in a day, but usually four or fewer) are seen during such spring tides at the Palo Alto Baylands, and occasionally individuals are observed in the East Palo Alto marshes as well. This species is likely present in small numbers at other scattered locations as well (e.g., there are unconfirmed reports from the Alviso marina during high winter tides), but the inaccessibility of most suitable areas to look for black rails during spring tides, and the species' silence in the South Bay during winter, makes it virtually impossible to survey the species in the Study Area during this season.

Late-season (April) calling black rails have been reported at the Palo Alto Baylands (26-27 April 1993; Santa Clara County Bird Data) and near the east end of the Dumbarton Bridge. There is also a 30 August 1995 record from the vicinity of the Sunnyvale Water Pollution Control Plan (presumably along Guadalupe Slough) (Santa Clara County Bird Data Unpublished). However, there are no records of black rails breeding in the South Bay since at least the 1920s (Trulio and Evens 2000).

The absence (or scarcity) of breeding black rails in the South Bay is presumably a result of habitat loss. Tidal marsh habitat has been lost, but perhaps more important to winter survival is loss of high-tide

refugia habitat. Upland transition habitat, both on natural levees within marshes and on landward edges of marshes, has been lost as a result of fill for development, and reductions in marsh size and resultant reductions in natural levees along higher-order channels. Predation by egrets, herons, gulls, and harriers has been observed in these marshes during winter high tides, as black rails are forced into the open by rising water. The importance of this predation on a population level, especially in light of impacts to high tide refugia, is unknown, but it may be a significant factor in the extirpation of breeding populations of the species from the South Bay.

Western Snowy Plover (*Charadrius alexandrinus nivosus*). Federal Listing Status: Threatened; State Listing Status: Species of Special Concern. The snowy plover is a small shorebird that occurs on almost every continent. In North America, there are two races of snowy plover: the western snowy plover (*C. a. nivosus*) occurs west of the Mississippi River, primarily in the Great Basin and along the Pacific coast, and the Cuban snowy plover (*C. a. tenuirostris*) occurs in the southeastern United States (Page et al. 1995). On the Pacific coast, snowy plovers nest on sandy beaches and salt panne habitat from Washington to Baja Mexico. Because they nest during the summer, primarily on beaches in a temperate climate, western snowy plovers are susceptible to nest disturbance and other negative interactions with humans. Much of their nesting habitat, particularly in southern California, has been lost to development and high human use. In addition, introduced predators, especially the non-native red fox, have had dramatic effects on snowy plover nesting success (Neuman et al. 2004). In response to severe population declines, the USFWS listed the Pacific coast population of the western snowy plover as Threatened in 1993. Critical habitat was designated for this population in 1999, and a draft recovery plan was released in 2001 (U.S. Fish and Wildlife Service 2001). None of the breeding sites within San Francisco Bay are considered critical habitat. The State of California lists the western snowy plover as a species of special concern.

In the South San Francisco Bay, snowy plovers nest on low, barren to sparsely vegetated salt pond levees and islands, at pond edges, and on salt panne areas of dry ponds (Page et al. 2000), and preferentially use light-colored substrates such as salt flats (Feeney and Maffei 1991; Marriott 2003). Nesting areas are located near water, where prey (usually brine flies and other insects) are abundant. In some areas, snowy plovers nest within dry salt ponds; in other areas where ponds typically hold water through the summer (e.g., the Newark salt ponds), nests are located primarily on levees. Often, nests are located near disruptive objects such as rocks or surface irregularities, and may be constructed in depressions created by footprints and vehicles (Marriott 2003; Page et al. 1995). Nests consist of a depression scratched into the substrate sometimes lined with shell fragments, pebbles, or similar local materials (Page et al. 2000; Page et al. 1995). Eggs are oval and buff-colored with small, brown- and black-colored spots and scrawls.

According to Page et al. (1995), pairing begins as early as mid February; egg-laying commences in early March, and may continue with multiple broods into early August. The incubation period ranges from 26 to 32 days. Three eggs are typically laid two to five days apart. Replacement clutches are initiated approximately six to eight days after the destruction of a completed clutch. Young birds are precocial, leaving the nest within hours of hatching. Chicks are usually cared for exclusively by the male parent, until they fledge at 28-33 days. Chicks feed themselves, but require the protection of an adult for brooding and evasion of predators. The breeding season of the western snowy plover in California, from

nest initiation to fledging of chicks, is considered to be 1 March to 31 September. Although snowy plovers can nest as early as 1 March, damp nesting substrate in salt ponds, from flooding or normal spring rains, may delay nesting in this habitat until the substrate dries.

Some snowy plovers remain in their coastal breeding areas year-round, while others are migratory. Some individuals that nest in the San Francisco Bay Area probably migrate south as far as Mexico (U.S. Fish and Wildlife Service 2001). There is overlap between the San Francisco Bay population and the adjacent coastal nesting population. Birds banded at Monterey Bay and in Oregon have been seen in the San Francisco Bay salt ponds (Feeney and Maffei 1991). Snowy plovers typically live three to four years (Page et al. 1995).

Snowy plovers in the South Bay forage primarily on small flies, especially brine flies (*Ephydra cinerea* and *Lipochaeta slossonae*; (Feeney and Maffei 1991). They also feed on other small invertebrates, including beetles and small marine invertebrates. Snowy plovers forage visually, and often run after prey which they capture in their bills. In the South Bay, western snowy plovers are likely to forage anywhere where prey is available. Brine flies are usually found in greatest densities at the shallow margins of shallow salt ponds or puddles, but snowy plovers also forage in open salt flats, and occasionally, on mudflats adjacent to salt ponds.

It is not known whether this species nested inside San Francisco Bay before conversion of salt marsh to salt evaporation ponds. Breeding habitat may have been present in natural salinas prior to the creation of salt ponds, but such features would have provided limited breeding habitat for snowy plovers, at best. Salt ponds have provided suitable nesting and foraging habitat since the beginning of the 20th century, and as of 1990, about 10% of the California population of snowy plovers bred within San Francisco Bay salt ponds, mostly in the southern part of the Bay (Page et al. 2000; Page et al. 1991). Surveys conducted by PRBO, SFBBO, and others since the 1970s have shown that the breeding population in the South Bay may be declining. Window surveys in the South Bay, which cover most available breeding habitat in a one-week period, detected 351 breeding birds in 1978, 270 in 1984, and 216 in 1989 (Page et al. 2000). In 2004, the results of breeding-season monitoring of the Eden Landing, Alviso, and Ravenswood pond complexes resulted in a maximum of only 113 snowy plovers (Strong et al. 2004b); this total was down to 99 birds in 2006 (Robinson et al. 2006). Numbers of snowy plovers in the South Bay may be considerably higher in winter, when the local population is augmented by wintering birds that likely breed in the Great Basin. In contrast, recent surveys by USGS (Takekawa et al. 2005) found lower abundance in winter in the Alviso pond complex.

Figure 6 depicts the areas where snowy plovers have been recorded breeding in the South Bay since 1989 (although no recent data are available from the Newark and Redwood City salt ponds). During both the winter and breeding seasons, the greatest concentration of snowy plovers in the San Francisco Bay area has consistently occurred in the Eden Landing/Hayward area, with a lower but moderate level of use at Ravenswood and Alviso ponds.

Within the Study Area, substantial breeding populations occur in the Warm Springs salt ponds (Ponds A22 and A23) in the Alviso complex. At Warm Springs, Ponds A22 and A23 are used, with > ten adults

found during the 2003 nesting season, a high count of 32 plovers at A22 in 2004 (Strong et al. 2004b), and 13 plovers at A22 in 2006 (Robinson et al. 2006). Low densities of snowy plovers have been recorded during the breeding season, sometimes with nests or chicks, at some other Alviso salt ponds, primarily at A6 and A8 (Ryan and Parkin 1998b; Strong et al. 2004b); the species also nested in the late 1990s in Alviso Pond A3N and in a small impoundment immediately east of Pond A12 (Santa Clara County Bird Data Unpublished). In 2006 and 2007, Pond A8 in Alviso has been used extensively by snowy plovers, after several years with very little plover activity in Alviso. In 2006, up to 36 snowy plovers were seen in A8, and 11 nests were found here (Robinson et al. 2006). In addition, the presence of snowy plover chicks and adults at an impoundment east of the Alviso Marina indicated that snowy plovers nested here, although no nest was found (Robinson et al. 2006).

Habitat conditions (including water depth and predator density) change over time at each of these nesting areas, so the numbers cited above are not necessarily representative of the current distribution of snowy plovers in the South Bay. The snowy plover is opportunistic, capable of moving around among potential breeding areas and breeding where conditions are suitable. The abundance and distribution of snowy plovers in the South Bay shifts annually, and is also dynamic within a given nesting season. Early in each breeding season, many ponds may not be suitable for nesting due to late rains creating muddy substrates, and nesting may be concentrated at a few ponds with suitable conditions. Later in the season, as more ponds dry out and become available for nesting, snowy plovers may be more dispersed among many nesting locations, and nest in lower densities.

Primary threats to the western snowy plover are mammalian and avian predators, and human disturbance (Page et al. 1995). Non-native predators, such as red fox, have had major effects on populations in California; in the South Bay, two snowy plover nests were known to have been depredated by red foxes in 1993 and 1994 in the Coyote Hills and Dumbarton areas (Harding et al. 1998), and such events have probably occurred much more frequently than is known. Efforts to curtail nest depredation by mammalian predators have greatly enhanced nesting success by snowy plovers in some areas (Neuman et al. 2004). In the South Bay, no strong increase in nest success was noted between 1991 and 1996, after a predator management plan was implemented, except at a few nests where exclosures were used; such nests had generally high success rates (Harding et al. 1998). Overall nest success in the South Bay has been fairly high in some recent years, with 80% nest success in 2001 (N=78 nests) and most of 2004 (N=54 nests as of July) (Wilson 2004). However, fledging success is unknown, and may be far less due to predation by avian predators.

Avian predators, particularly California Gulls and corvids (crows and ravens), are increasingly becoming an issue for snowy plover reproductive success (Wilson 2004). California gulls at Mono Lake are known to prey on snowy plover eggs and chicks (Page et al. 1983), and given the abundance of California gulls in the South Bay during the breeding season, even low levels of predation may be important to nesting plovers. American Crows (*Corvus brachyrhynchos*) and common ravens are adept at finding snowy plover nests and preying on eggs. Corvid numbers may be increasing throughout California, at least partially in response to increased availability of food from anthropogenic sources, such as garbage dumps. Other avian predators, including Loggerhead Shrikes, American Kestrels, and Northern Harriers have been documented taking snowy plover chicks, and in some areas, have dramatically reduced fledging

success (Neuman, pers. comm.). Human disturbance can also be a serious factor limiting nesting and fledging success. Human disturbance (including disturbance from domestic dogs) can lead to nest abandonment or direct trampling of eggs or chicks (Page et al. 1995). In addition, because young chicks are dependent on adults for protection, human disturbance resulting in the separation of chicks from adults can lead to the death of the chicks.

California Least Tern (*Sterna antillarum browni*). Federal Listing Status: Endangered; State Listing Status: Endangered. Least terns are small fish-eating birds that nest primarily on beaches. The California least tern nests during summer from Baja California north to San Francisco Bay. Least terns are migratory, and spend winter months in coastal areas of Mexico and Central America. Most breeding colonies are located in southern California. The California least tern is listed as endangered on the state and federal levels, and the state considers it a fully protected species.

Currently, the breeding colony at Alameda is one of the most important breeding colonies in the state. In 2003, this colony had 301 breeding pairs (Hurt 2004). This total is up considerably from prior decades: 128 pairs were found in 1993, and only 70 pairs nested in 1982 (Collins 1994). Least terns nesting at Alameda typically arrive at the colony in late April, and fledge chicks from late June to early August. They forage for small fish in shallow coastal waters near the colony, mainly around Alameda Point (Hurt 2004). Adults and juveniles typically start dispersing south from the Alameda colony in early July.

Least terns also nested in 2000 and 2001 at Albany (near Alameda), with up to 12 pairs in 2000. At Pittsburg, on Suisun Bay, 13 pairs nested in 2001 and eight pairs nested in 2003. Historically, small numbers of birds have nested at the Oakland International Airport (last reported in 1995), Bay Farm Island (last reported 1975), Bair Island (last reported 1984), Port Chicago (last reported in 1988), the Bay Bridge Sand Spit (one-time attempt in 1985), and tern Island (one-time attempt in 1990) (Takekawa et al. 2005).

In addition, South Bay salt ponds have been used historically for sporadic and limited nesting attempts. These include attempts on levees at Ponds E10/E11 at Eden Landing (last reported 1985), Ponds N5/N7 (last reported 1983) and N1A in the Newark salt ponds, and Pond R3 in the Ravenswood Complex (Hurt 2004; Wetlands Research Associates 1994). In the South Bay, recent breeding has occurred only at Hayward Regional Shoreline, where eight pairs nested in 2005 and 15 pairs in 2006 (Strong 2006), and at Pond E8A in Eden Landing, where at least five pairs nested in 2007.

Currently, least terns use the Shoreline Study Area only as a post-breeding staging area from about late June through late August, prior to their southward migration. Here, both adult and juvenile least terns roost on salt pond levees (both outboard levees and interior levees between ponds) and boardwalks, and forage both in the salt ponds and over the open waters of the Bay. At the Alameda colony, least terns forage primarily on silversides (e.g., topsmelt), northern anchovies, Pacific herring, and surfperches (Elliott et al. 2004). Although data are unavailable regarding diet during the post-fledging period in the South Bay, diet is likely similar. Least terns have often been observed foraging in South Bay salt ponds, but they also forage heavily in adjacent open Bay waters. For example, 50 of 58 least terns observed foraging in the SBSP project area on 14 July 2004 were doing so over the Bay, with only eight

individuals actively foraging in salt ponds (Steve Rottenborn, pers. obs.). However, the relative importance of salt ponds versus Bay waters for foraging by least terns in the South Bay is largely unknown.

In recent years, the main post-breeding (late summer/fall) staging area for least terns in the South Bay has been in the complex of salt ponds immediately north of Moffett Field (Ponds AB1, A2E, and AB2; Figure 5), located in the Study Area. For example, 276 least terns were seen in these three ponds on 27 July 2004 (Steve Rottenborn, pers. obs.). This site is used predictably for roosting and foraging by both adult and juvenile least terns in July and August each year, with typical counts of 20-100 birds. Least terns have also been recorded at a number of other ponds in the Study Area, including A1, A2E, A3N, A3W, A4, A5, A7, A9, A10, A11, and A14 (Hurt 2004).

Salt Marsh Harvest Mouse (*Reithrodontomys raviventris raviventris*). Federal Listing Status: Endangered; State Listing Status: Endangered. The salt marsh harvest mouse is a small mouse endemic to salt marshes of San Francisco Bay. The USFWS listed the salt marsh harvest mouse as an Endangered Species under the authority of the Federal Endangered Species Act on 13 October 1970, based on population declines and loss of habitat. The State of California listed the salt marsh harvest mouse as an Endangered Species on 27 June 1971, and considers it a fully protected species. The USFWS approved a joint recovery plan for the salt marsh harvest mouse and the California clapper rail on 16 November 1984 (U.S. Fish and Wildlife Service 1984). Critical habitat has not been established for either the California clapper rail or salt marsh harvest mouse.

The salt marsh harvest mouse's current distribution includes salt marshes in San Francisco, San Pablo, and Suisun Bays. The species no longer occurs on the Peninsula north of Coyote Point (Shellhammer 2000a). *Reithrodontomys raviventris* is separated into two subspecies, *R. r. raviventris* of the South Bay and *R. r. halicoetes* of the North Bay. *R. r. raviventris* is restricted along both sides of San Francisco Bay to an area from San Mateo County on the west side and Alameda County on the east side, south to Santa Clara County; this subspecies was one of the pivotal species upon which the decision to initially establish a National Wildlife Refuge in the South San Francisco Bay was based (H.R. Bill 17047, (1970), and Senate Bill 2291, (1969)).

These mice are dependent on dense vegetative cover, usually in the form of pickleweed and other salt dependent or salt tolerant vegetation in both tidal and diked salt marshes (Fisler 1965; Shellhammer 1982; Shellhammer 2000a; Shellhammer et al. 1988; Shellhammer et al. 1982). Pickleweed provides more horizontal branches (and therefore more cover) than other halophytic species. Closely tied to the cover of dense pickleweed, salt marsh harvest mice were thought to make little use of pure alkali bulrush or pacific cordgrass stands (Shellhammer 1977; Wondolleck et al. 1976). More recent trapping (H. T. Harvey & Associates 2007) detected salt marsh harvest mice in brackish marshes dominated by alkali bulrush. The extent of their distribution in, and use of, this habitat is not yet known. Grasslands adjacent to pickleweed marshes are generally used only in the spring when new growth affords suitable cover and possibly forage (Johnson and Shellhammer 1988). Salt marsh harvest mice may also use adjacent grasslands on a daily basis to avoid high tide events, but only a small percentage of the edge of the South Bay has grassland or even much in the way of escape cover adjacent to it, hence the salt marsh harvest mice have almost

nowhere to go to escape from high tides. Refugial vegetation, especially peripheral halophytes, is necessary in tidal marshes and in diked marshes that flood seasonally. On the highest spring tides in winter, the lack of high-tide refugia exposes salt marsh harvest mice to intense predation, and numerous small mammals (many of which are likely salt marsh harvest mice) have been observed being depredated by gulls, herons, egrets, and raptors on such high tides in the South Bay. Marshes without appropriate cover, and narrow marshes without refugial zones into which the mice can escape during flooding or high tides, generally lack salt marsh harvest mice. Figure 7 depicts areas currently providing pickleweed habitat that is known to support, or could potentially be supporting, salt marsh harvest mice within the Study Area and adjacent areas, as well as locations where this species has and has not been detected during survey efforts, and locations providing suitable escape cover; relatively few areas provide high-quality habitat.

Salt marsh harvest mice build loose nests of dry grasses (Shellhammer 1982). Average litter size ranges from 3.7 to 4.2 mice/litter and most animals are thought to have only one litter/year (Fisler 1965). However, recent evidence shows more frequent reproduction (Geissel et al. 1988), with Grizzly Island Wildlife Area populations reproducing as often as three times per year (Krause, pers. comm.). Reproduction occurs from March through November (Fisler 1965). There are few data on foraging by harvest mice, but they probably subsist on leaves and stems of plant species, primarily pickleweed, found in tidal and diked salt marshes. Fisler (1965) reported a high seasonal variation in stomach contents. In winter, fresh green grasses were preferred, while in the rest of the year, pickleweed and other halophytes such as salt grass were the main food sources. The salt marsh harvest mouse is capable of drinking pure seawater, but it generally prefers brackish water (Fisler 1965).

Historically, the marshes in San Francisco Bay were a complex mosaic of vegetation zones, generally consisting of low marsh adjacent to mudflats dominated by cordgrass, high marsh plains dominated by pickleweed, and broad transitions of peripheral halophytes (salt-tolerant plants that cannot tolerate as much inundation by the tides) into upland habitats, with narrower transitional zones on natural levees along larger channels within the marshes. Most of the tidal marshes around the Bay and especially in the South Bay were eliminated, and those remaining have lost the upper portion of their pickleweed zones as well as the higher zone of peripheral halophytes (Shellhammer 1982; Shellhammer and Duke 2004). For example, detailed mapping by H. T. Harvey & Associates for the South Bay Salt Pond Restoration project reveals that pickleweed dominated habitat and peripheral halophyte habitat comprise only 275 acres and 113 acres, respectively, within the 8000-acre Alviso Complex; much of the peripheral halophyte acreage in the Alviso Complex, however, is adjacent to little used brackish vegetation. Most of the tidal salt marshes in the South Bay are small, isolated strip-like marshes along backshores against levees or other hardened structures that promote predation, inhibit further high marsh development, and are threatened by sea level rise (Shellhammer 1989). Similarly, most of the marshes do not have higher order tidal channels within them and hence lack a pattern of natural levees supporting shrubs such as gum plant, and other peripheral halophytes, within them that might act as escape cover for mice within the marshes. Shellhammer and Duke (2004) note that most of the marshes of the South Bay are de facto corridors, likely not wide enough to support viable populations, but wide enough to function as dispersal corridors. Recent mapping is also documenting the fragmentation of the habitat (Figure 7). Cover-dependent salt marsh harvest mice are unlikely to move long distances over bare areas, and thus, isolation of suitable

habitat may lead to genetic isolation of populations. While they are known to swim well, especially in comparison with western harvest mice, they have not been documented to move more than four to five meters across water or more than five meters over bare ground (Bias 1994; Geissel et al. 1988). Based on this information, Shellhammer and Duke (2004) have hypothesized that barren areas of land more than five meters wide, reaches of water more than four meters wide, and brackish or freshwater marsh more than 250 meters wide act as barriers to movement of the southern subspecies of the salt marsh harvest mouse, and hence barriers to gene flow. The more recent (2006) discovery of salt marsh harvest mice in brackish marshes tempers the description of barriers somewhat, but there are still broad areas without vegetation. Areas of bare ground, water, or fresh/brackish marsh less than or equal to these distances may act as filters, reducing the movement of animals (and hence the rate of gene flow) between populations or between portions of a semi-fragmented population. The isolation of populations has contributed to the decline of the species (Shellhammer and Duke 2004) and could lead to local extinctions due to demographic processes or genetic “death.” Based on their assessment of potential barriers in the South Bay, Shellhammer and Duke (2004) estimated that there were potentially 25 separate populations of salt marsh harvest mice in the South Bay as of 2002 (not including mice that might be present in very small patches of pickleweed). Figure 7 indicates the locations of major barriers and filters to dispersal of salt marsh harvest mice among the tidal salt marsh remnants in the South Bay.

Habitat degradation has also occurred as a result of the conversion of existing tidal salt marsh to brackish or even freshwater marsh over the past four decades. Within the Alviso Complex, the combination of treated effluent discharge, sedimentation that has reduced the tidal prism, and freshwater flows from rivers and streams (especially in high-rainfall years) has created conditions too fresh for pickleweed to compete and survive (H. T. Harvey & Associates 1994; 2002; 2006; Shellhammer 1982; Shellhammer et al. 1988; Shellhammer et al. 1982). The habitat value of brackish marsh needs reexamination after recent results in the Suisun Marsh and more recently in Alvios. Trapping in salt marsh harvest mouse preserves in the range of the northern subspecies in the Suisun Bay by Barthman-Thompson of CDFG has shown that salt marsh harvest mice do use other species of bulrush and cattail (*Typha* spp.) in the area. Preliminary results from a number of mouse trapping projects (most of which were done in the Suisun Bay) suggest that monocultures of peppergrass, which dominate large areas of brackish marsh in the South Bay, are not used by the mice.

As a result of habitat loss, degradation, and fragmentation, salt marsh harvest mouse populations are small. A database for all salt marsh studies carried out in the South San Francisco Bay, including the entire Study Area, was compiled by H. Shellhammer at H. T. Harvey & Associates (Shellhammer and Duke 2004). Trapping records from permits issued by the USFWS and the CDFG were reviewed and compiled. The database, which includes 198 trapping projects (estimated 95% of all such projects and studies) representing 134,204 trap nights (TN) completed through 2003, shows that 37% of all trapping projects (73 of 198, or 49,481 TN of a total of 134,204 TN) captured 0 salt marsh harvest mice. The average capture efficiency (CE, or total effort in TN divided by the number of mice captured) of all trapping projects was 0.013. In terms of unit effort, it took an average of 79 TN to capture one salt marsh harvest mouse. The approximately 64% of the projects in which at least one mouse was captured (153 of 198) had a capture efficiency equal to or less than 0.019, or it took 77 TN to capture a single mouse.

There were few projects in which numerous salt marsh harvest mice were captured; there were only eight projects with a CE \geq 0.06.

The Alviso ponds have had 11 projects in the New Chicago Marsh area (mostly from the 1970s and 1980s), and 11 or more in Triangle Marsh and its western extension (north of Alviso), but again most of them date from the 1970s and 1980s. There are nine or more, widely spaced projects in the middle of the Alviso Complex: two were done along Guadalupe Slough, six on or near the northwestern edge of Moffett Field, and one in the southeastern corner of the Sunnyvale Baylands Park. The highest density of trapping projects in the area of the Alviso Complex is just west of the complex, where 13 projects have been carried out between Charleston Slough and San Francisquito Creek. Most of the harvest mouse trapping projects were carried out in the late 1980s and 1990s. A relatively small number of projects have been carried out in these ponds compared to other parts of the South Bay because they were protected from development for most of the last few decades.

Despite the species' small populations, the salt marsh harvest mouse is known to rapidly colonize restored areas. This species quickly moves into areas of appropriate habitat from nearby inhabited areas as has been shown in numerous trapping projects' reports, including many in the South Bay (H. T. Harvey & Associates 1984a; 1985a; 1985b; 1985c; 1987; 1996; 1997a).

4.4.2 Other Special-Status Species

Western Pond Turtle (*Clemmys marmorata*). Federal Listing Status: None; State Listing Status: Species of Special Concern. The western pond turtle is an aquatic turtle found west of the Sierra Nevada from the Columbia River south to northern Baja California, Mexico. This turtle requires some slack or slow water, although it will occur where enough food resources occur in faster moving water; it usually leaves the aquatic site to reproduce, to aestivate, and to over-winter. Typical habitat includes freshwater ponds and backwaters in slow-moving rivers with abundant aerial and aquatic basking sites. Nesting usually occurs in upland areas from March to July, in hard-packed clay soil. Hatchlings disperse from the nest with winter rains. Threats to the western pond turtle include impacts to nesting habitat from agricultural and grazing activities, human development of habitat, and increased predation pressure from native and non-native predators as a result of human-induced landscape changes. Many of the current records for the species are from the greater San Francisco Bay area, including the Santa Clara Valley (Jennings and Hayes 1994).

Western pond turtles are absent from most of the Shoreline Study Area, due to a lack of suitable freshwater habitat. A small population occurs in brackish habitats near Moffett Field and the Sunnyvale WPCP, in the vicinity of Pond A3W (Alderete and McGowan 2003; Figure 5). Here, up to five turtles were found on 31 May 2002, in the Northern Channel on the south side of A3W (Alderete and McGowan 2003). This population is clearly isolated from other pond turtle populations in the South Bay. A review of western pond turtle records in Santa Clara County in 1999 (H. T. Harvey & Associates 1999b) included a single record along lower Stevens Creek near Moffett Field from 1987, but the next closest records to Moffett Field were more than seven miles away at Lagunita at Stanford, along San Francisquito

Creek in Palo Alto, and in a pond along San Tomas Aquino Creek in Santa Clara. Pond turtles are occasionally seen along lower Coyote Creek and the Guadalupe River; these are likely individuals that have dispersed downstream from populations in the upper watersheds of these streams.

Double-crested Cormorant (*Phalacrocorax auritus*). **Federal Listing Status: None; State Listing Status: Species of Special Concern (Rookery Site).** Double-crested cormorants are large fish-eating waterbirds resident along the entire coast of California and on inland lakes and estuaries. Breeding occurs at undisturbed sites, typically in trees or on man-made structures beside water. Double-crested cormorants are considered Species of Special Concern by the CDFG only at rookery sites. Double-crested cormorants nest during spring and summer (and occasionally into early fall), and are resident in the South Bay year-round. Numbers are augmented considerably in fall and winter, when non-breeding birds from other locations visit San Francisco Bay (Ainley 2000b).

Double-crested cormorants have increased as breeders in the San Francisco Bay area in recent decades. First breeding records for Alameda County, the bayside of San Mateo County, and Santa Clara County were established only as recently as 1984, 1989, and 1992, respectively. As of 1991, there were approximately 2800 double-crested cormorants nesting around San Francisco Bay, primarily on North Bay bridges (Ainley 2000b). Relatively few, however, breed in the Study Area. Here, this species has recently nested on electrical transmission towers at several sites, including towers in ponds A18, AB1, AB2, and A2W ((Strong 2004a); Figure 5). Santa Clara County Bird Data indicate that cormorants were first recorded nesting in the Alviso Complex on electrical towers in Pond A2W in 1992. Nesting by as many as ten pairs/year at this location has continued through 2004, and new colonies appeared on towers in Ponds AB1/AB2 in 1993 (with up to eight nests in subsequent years) and Pond A18 in 1994 (with a high of 27 nests in 1997). In 2006, 34 nests were counted at Pond A2W (Strong 2006). Double-crested cormorants use salt pond levees in the South Bay primarily for roosting, but a colony established in 1998 on the levee between Ponds A9 and A10 has contained up to 70+ nests in years since. In 2006, 29 nests were counted on this levee (Strong 2006).

These birds probably forage primarily in the open Bay, but cormorants also forage for fish in salt ponds. Counts from USGS censuses in South Bay salt ponds from 2002 through 2004 peaked in October and November, with high counts of 1963 at the Alviso Ponds in October 2003 (Takekawa et al. 2005). Numbers during surveys by USGS were lowest from January through March, with high counts typically under 100 birds at the Alviso Ponds. Large foraging flocks occasionally form around high fish concentrations, as indicated by counts of 1550 in Pond A9 on 9 October 2000 and 1200 on Shoreline Lake in Mountain View on 16 November 1996 (Santa Clara County Bird Data Unpublished).

White-faced Ibis (*Plegadis chihi*). **Federal Listing Status: None; State Listing Status: Species of Special Concern (nesting colony).** The white-faced ibis is a medium-sized wading bird that is an uncommon breeder in California; it is considered a Species of Special Concern only at nesting colonies. White-faced ibises have nested at only a few locations in California, including the Salton Sea, Honey Lake, isolated locations in the Central Valley, and at Mallard Slough, in the South Bay. Currently, most ibises in California now nest at Kern NWR, in the Central Valley. Nests are built of vegetation, in dense stands of tule, cattail, or similar marsh vegetation.

The only nesting by the white-faced ibis in the South Bay occurred at Mallard Slough (also known as Artesian Slough), between Ponds A16 and A18 (Figure 5). Here, six adults were observed in and around a large mixed-species heronry in 1985, and adults were seen carrying nesting material in 1991 and 1992 (Santa Clara County Bird Data Unpublished). However, successful breeding was not documented, and there has been no subsequent evidence of breeding by this species in the South Bay since that time. White-faced ibises occur irregularly throughout the San Francisco Bay Area during the nonbreeding season.

Northern Harrier (*Circus cyaneus*). Federal Listing Status: None; State Listing Status: Species of Special Concern (nesting). The Northern harrier is a raptor commonly found in open grasslands, agricultural areas, and marshes. Nests are built on the ground in areas where long grasses or marsh plants provide cover and protection. Harriers hunt for a variety of prey, including rodents, birds, frogs, reptiles, and insects by flying low and slowly in a traversing manner. The Northern harrier is considered a Species of Special Concern in California only at nesting sites.

This species is a common forager over San Francisco Bay marshes and extensive areas of ruderal habitat immediately surrounding the Bay, particularly during the non-breeding season (winter) when migrant and wintering birds augment the local resident population. Northern harriers breed in low numbers within the South Bay, nesting in the larger expanses of tidal marsh that remain, such as Triangle Marsh in Alviso, the Warm Springs marshes, and the Palo Alto/East Palo Alto marshes. This species also nests in extensive tracts of tall ruderal vegetation, moist fields, and nontidal or muted tidal marsh, such as occurs on Moffett Field and in the Palo Alto Flood Control Basin. The minimum patch size needed to support a pair of nesting harriers in the South Bay is unknown, and the narrow strips of marsh along some of the sloughs between salt ponds in the Study Area are likely too narrow to provide suitable nesting habitat for this species. However, nest-building along Guadalupe Slough near the Sunnyvale WPCP in 1993 and a successful nesting along Mountain View Slough, between Ponds A1 and A2W in Mountain View, in 2000 indicates that some of these narrower marshes do provide suitable nesting habitat (Santa Clara County Breeding Bird Atlas Committee Unpublished). Northern harriers may be important predators of nesting shorebirds and terns in the South Bay, with individuals or pairs keying in on certain areas having concentrations of nesting waterbirds. This species has been known to take both adult and young snowy plovers in the Eden Landing Complex (Krause, pers. comm.).

White-tailed Kite (*Elanus leucurus*). Federal Listing Status: None; State Listing Status: Fully Protected Species. This raptor species prefers habitats with low ground cover and variable tree growth. Kite nests are usually built near the tops small trees or large shrubs near open habitats, such as partially cleared or cultivated fields, grassy foothills, and marsh. Kites prey primarily on small rodents (especially the California vole), but also feed on birds, insects, reptiles, and amphibians.

This species occurs in the South Bay commonly throughout the year, primarily in the upland fringes of the Shoreline Study Area. Breeding occurs primarily in spring and early summer, although breeding activity as early as February, with young in the nest as late as October, has been noted in the South Bay (Santa Clara County Bird Data Unpublished). This species breeds in a number of locations around the

Study Area where nest sites (e.g., trees and shrubs) occur adjacent to open fields, ruderal habitats (e.g., active and closed landfills), and marshes. The riparian corridor of Coyote Creek is likely to support several breeding pairs each breeding season.

Merlin (*Falco columbarius*). Federal Listing Status: None; State Listing Status: Species of Special Concern (wintering). The merlin is a medium-sized falcon that breeds in North America primarily in Canada. Merlins do not breed in California, but have been listed as a Species of Special Concern due to concerns over the species' wintering populations here. Non-breeding merlins occur in the San Francisco Bay area from September through April.

Like most falcon species, the merlin feeds primarily on small birds. Merlins are widespread, but in low abundance, throughout the entire Bay area during migration and winter, where they forage aerially. Shorebirds (e.g., sandpipers) provide abundant prey, thus merlins can often be found foraging over salt ponds and mudflats. They also forage on a variety of other bird species, and can be found in virtually all habitats in the Shoreline Study Area.

California Gull (*Larus californicus*). Federal Listing Status: None; State Listing Status: Species of Special Concern (nesting colony). The California gull breeds colonially throughout the western United States, often in colonies of several thousand birds. They typically start attending colonies in early April, and lay eggs in early May (Winkler 1996). Incubation takes about 27 days, and chicks hatch in the late May to early June. Chicks remain near the nest until fledging about six weeks after hatching. Typical nesting habitat is barren or sparsely vegetated borders of saline lakes. Abundant nesting populations from the Great Basin (e.g., Great Salt Lake) disperse to coastal California after breeding, greatly augmenting the wintering population in the Bay area.

Historically, California gulls bred primarily on saline inland lakes, and this species was declared a Species of Special Concern at nesting colonies by CDFG due to concern over impacts to inland breeding colonies. In 1980, a small group colonized abandoned levees on Pond A6 in Alviso. This colony steadily increased in size over the next two decades, and by 2000 this colony had grown to over 10,000 nesting individuals, making it the second largest colony in California (Shuford and Ryan 2000). Adult California gulls attend the Pond A6 colony year-round, but numbers increase during spring. Egg laying occurs between mid-April and mid-May, and most young are fledged by mid-August (Shuford and Ryan 2000). Adult California gulls breeding in the South Bay forage on natural prey, such as brine flies and their larvae, and brine shrimp, supplemented by food obtained from human sources, including the Newby Island Landfill near Milpitas and the Tri-Cities Landfill in Fremont. It is likely that the availability of food at these landfills has been at least partly responsible for the increase in South Bay breeding populations, both by providing food during the breeding season and by aiding in the survival of younger birds during the nonbreeding season.

California gulls also prey on the eggs and young of other birds, such as snowy plovers, Forster's terns, American avocets, and black-necked stilts, and they likely take small mammals such as salt marsh harvest mice as well. A study by Ackerman et al. (2006) documented that 15% of American avocet nests monitored with cameras in the South Bay were depredated by California gulls; 61% of American avocet

chicks and 23% of black-necked stilt chicks fitted with radio transmitters in this study were determined to be depredated by California gulls. California gulls at Mono Lake are known to prey on snowy plover eggs and chicks (Page et al. 1983), and given the abundance of California gulls in the South Bay during the breeding season, even low levels of predation may be important to nesting waterbirds. Salt marsh harvest mice are particularly vulnerable during extreme high tide events, when most of the pickleweed marsh plains of the South Bay are completely inundated. At these times, salt marsh harvest mice are forced to swim, and gulls (including California gulls) readily forage over the flooded marshes, presumably including salt marsh harvest mice among their prey.

California gulls also nest in smaller numbers at several other sites within the Study Area. As of 2004, they were nesting in at least five colonies in the South Bay. Figure 2 depicts the locations where this species has nested in the South Bay since 1994. In 2006, the largest colonies other than at Pond A6 were at Coyotes Hills ponds 2A/3A (3721 nests) and on the levee between ponds M1 and M2 (2492 nests; Strong 2006). Numbers of California gulls in the South Bay increase during winter, when the local population is augmented considerably by birds moving from interior populations.

Table 9 – Numbers of California gulls at colonies in ponds in the Shoreline Study Area, from 1982 to 2006. All numbers are either total number of adults counted on the colony, or twice the number of nests counted on the colony. Data from Strong (Strong 2004b, Strong 2006).

Year	A1	AB2	A6	A9/10
1982	0	0	412	434
1983	0	0	1342	0
1984	0	0	2000	150
1985	0	0	3000	374
1986	0	0	3000	97
1987	0	0	4000	100
1988	0	0	4600	180
1989	0	0	5310	434
1990	2	0	7600	122
1991	0	0	5250	0
1992	0	0	5500	200
1993	200	82	6912	234
1994	350	556	9000	300
1995	74	300	7236	4
1996	0	282	6558	1410
1997	164	1000	6256	1722
1998	0	400	6562	1628
1999	145	248	9380	2117
2000	0	254	11482	1986
2001	278	624	11216	3056
2002	510	712	11302	3590

Year	A1	AB2	A6	A9/10
2003	862	384	13644	1010
2004*	445	531	8600	1047
2006	190	187	9726	117

*Numbers are based on a single aerial survey, and are likely underestimates.

Black Skimmer (*Rynchops niger*). Federal Listing Status: None; State Listing Status: Species of Special Concern (nesting colony). The black skimmer is a unique species, with a lower mandible longer than the upper mandible. This extended lower mandible allows these birds to fly over the surface of the water, skimming for small fish. Black skimmers nest primarily on the coasts of the Southeast United States, the Gulf of California, and the Pacific Coast of Baja, California, north to San Diego, and in California, the black skimmer is a Species of Special Concern only at nesting sites.

Black skimmers were first detected nesting in California in 1972, and since that time, this species' populations have increased considerably (e.g., to approximately 1200 pairs in 1995 (Collins and Garrett 1996). Until the mid-1990s, the black skimmer was considered a very rare nonbreeding visitor to the San Francisco Bay area. However, the species was documented nesting in San Francisco Bay in 1994, when one pair nested in Pond AB2 in Santa Clara County, and one pair nested at Hayward Regional Shoreline in Alameda County (Layne et al. 1996). Since 1994, this species has occurred in the South Bay every year and has nested at several additional sites in the Study Area, including ponds A1, A2W, AB1, A8, and A16 ([Strong 2004b]; Figure 5). In these areas, black skimmers have usually nested among Forster's terns, on small dredge-spoil islands (including both bare islands and islands vegetated, sometimes heavily, with pickleweed) in salt ponds. Exact nesting locations vary from year to year.

Skimmer populations in the South Bay have slowly but steadily increased (e.g., to a high count of 27 in Pond A8 on 28 September 2003; [Santa Clara County Bird Data Unpublished]). Because nesting success in the South Bay has apparently been low, judging by the low number of chicks surviving to fledging age, this population increase has likely been primarily the result of immigration from the increasing southern California population. Within the Shoreline Study Area, the species is most abundant in the vicinity of the Alviso Complex and most post-breeding flocks have been recorded in this area (e.g., on Pond A8 and in Charleston Slough).

Burrowing Owl (*Athene cunicularia*). Federal Listing Status: None; State Listing Status: Species of Special Concern. The burrowing owl is a small, terrestrial owl of open country. Burrowing owls occupy grasslands and sparsely vegetated shrubland ecosystems. In California, burrowing owls are found in close association with California ground squirrels. Ground squirrels provide nesting and refuge burrows, and maintain areas of short vegetation height, providing foraging habitat and allowing for visual detection of avian predators by burrowing owls. Burrowing owls are semi-colonial nesters, and group size is one of the most significant factors contributing to site constancy by breeding burrowing owls. The nesting season, as recognized by the California Department of Fish and Game, runs from 1 February through 31 August.

Burrowing owl populations in the South San Francisco Bay have been decreasing rapidly and significantly in recent decades. As of 1990, the South Bay burrowing owl population was thought to have declined at least 50% since 1981 (Barclay et al. 1998). A statewide census, the largest and most comprehensive undertaken to that date or since, suggested that the rate of disappearance of South Bay burrowing owls was greater than the rate found for owls in the Central Valley, and that the rate of decline for both regions was accelerating (DeSante et al. 1993; DeSante et al. 1997). A new statewide census was conducted in 2006. Surveyors on this census counted 595 burrowing owls statewide, of which 56 were in Santa Mateo and Santa Clara County.

Despite recent declines, burrowing owls still breed in a number of locations offering suitable burrows and open foraging habitat around the upland perimeter of the South Bay. Such sites include Byxbee Park in Palo Alto, Shoreline Park and Moffett Field in Mountain View, the Sunnyvale Baylands Park, the San Jose/Santa Clara WPCP buffer lands, and the SFBNWR lands in Fremont, and a few other scattered locations in the Shoreline Study Area (Figure 8). Burrowing owls are occasionally observed in shoreline, rocky, and upland habitats that rim the South Bay, and they are believed to nest at least infrequently in salt pond levees (Trulio 2000).

Short-eared Owl (*Asio flammeus*). Federal Listing Status: None; State Listing Status: Species of Special Concern (nesting). Short-eared owls occur in open habitats such as grasslands, wet meadows, and marshes. They require tall herbaceous vegetation for nesting or daytime refuge. Short-eared owls once bred much more widely in California, including the San Francisco Bay Area. However, the species now occurs primarily as a migrant and winter visitor, and is a rare and local breeder in the South Bay. The most recent nesting record in the South Bay was of three pairs producing four fledglings at Bair Island in 1994 (Yee et al. 1994). Other breeding-season records in the South Bay include a pair at the Palo Alto Baylands in 1966 (Chase and Chandik 1966) and two nests in the Palo Alto Flood Control Basin in 1972 (Gill 1977). The species is apparently much more abundant in the North Bay, with over 100 fledglings banded at Grizzly Island (Solano County) in 1987 (Campbell et al. 1987). Potential breeding habitat does occur in the Study Area, but the status of this species as a breeder in the Study Area is unknown. If short-eared owls currently breed in the South Bay, they are likely to nest only in the larger tracts of suitable habitat.

During winter, the species is more widespread, though in low numbers, with many records from bayside locations virtually throughout the Study Area. Locations of more regular observations in winter include Byxbee Park and the Palo Alto Flood Control Basin. Short-eared owls are considered Species of Special Concern only at nesting sites.

Cooper's Hawk (*Accipiter cooperii*). Federal Listing Status: None; State Listing Status: Species of Special Concern. The Cooper's hawk is a medium-sized raptor that preys upon smaller birds (e.g., jays, doves, and quail) and occasionally takes small mammals and reptiles. The Cooper's hawk prefers landscapes where wooded areas occur in patches and groves which facilitates the ambush hunting tactics employed by this species. Breeding pairs in California are often found in stands of live oak woodland or riparian areas, although this species has adapted well to suburban habitats and tolerates human activity. Cooper's hawks typically nest between March and August. During winter, local Cooper's hawks may

migrate south, while the local population may increase with immigration of migrants that breed farther north.

Within the Study Area, Cooper's hawks have been found nesting in suburban areas fringing the South Bay. They may nest in a variety of trees in this area, and may also nest in the riparian corridor of Coyote Creek.

Loggerhead Shrike (*Lanius ludovicianus*). Federal Listing Status: None; State Listing Status: Species of Special Concern (nesting). These predatory songbirds are year-round residents in grassland and scrub habitats in California. Shrikes generally build their nests in shrubs and trees in fairly open areas, and nest in spring and early summer. They hunt in open areas, usually from a low perch, such as a fence post or overhead wire. They forage primarily on large insects, lizards, and small mammals, but some individuals also prey on snowy plover chicks and other young shorebirds. Loggerhead shrike numbers have declined dramatically in eastern North America, but populations in California may be more stable. Loggerhead shrikes are considered Species of Special Concern only at nesting sites.

The species nests in low numbers throughout the Shoreline Study Area. Loggerhead shrikes are found in a number of locations around the Study Area where nest sites (e.g., trees and shrubs) occur adjacent to open fields, ruderal habitats (e.g., active and closed landfills), and marshes. Shrikes forage in ruderal habitats, on salt pond levees, and in marshes in the Study Area.

California Horned Lark (*Eremophila alpestris actia*). Federal Listing Status: None; State Listing Status: Species of Special Concern. Horned larks are songbirds that occur over much of North America in bare ground habitats with short grass, scattered bushes, or no vegetation. In winter, they often form large flocks that sometimes contain several subspecies. The California horned lark is a widespread breeder along the coast and in the Central Valley of California. They breed from March through July, with peak activity in May. Horned larks build grass-lined nests directly on the ground, in dry, open habitats with sparse vegetation.

Horned larks occur primarily as migrants and winter visitors in the Shoreline Study Area, when they may be found in small numbers foraging along salt pond levees, in salt pannes within dried-out salt ponds, and in short grassland and ruderal habitats (e.g., active and closed landfills) around the South Bay. A few pairs likely breed in these locations as well, as evidenced by scattered breeding-season records in and around the Alviso Pond Complex (Steve Rottenborn, pers. obs.; Santa Clara County Bird Data Unpublished).

Saltmarsh Common Yellowthroat (*Geothlypis trichas sinuosa*). Federal Listing Status: None; State Listing Status: Species of Special Concern. The saltmarsh common yellowthroat is a small songbird that inhabits emergent vegetation, primarily in fresh and brackish marshes, and associated upland areas in the San Francisco Bay Area. This subspecies (one of approximately 12 subspecies of common yellowthroat recognized in North America) breeds from mid-March through early August, and pairs frequently raise two clutches/year. Because this subspecies cannot be reliably distinguished in the field from other races that occur in the South Bay as migrants, determination of the presence of saltmarsh

common yellowthroats can be achieved only by observation of presence during the summer months when other subspecies are not expected to be present. Although little is known regarding the movements of this taxon, the wintering areas have been described as coastal salt marshes from the San Francisco Bay region to San Diego County (Terrill 2000).

Despite their common name, saltmarsh common yellowthroats breed primarily in fresh and brackish marshes, and in freshwater riparian habitats. In the South Bay, this species is a fairly common breeder in such habitats virtually wherever they occur, although very small patches of marsh often lack this species. Particularly large populations occur in brackish and freshwater marshes in the Alviso Complex (e.g., along the middle and upper reaches of the major sloughs and in the Warm Springs/Alviso marshes). The saltmarsh common yellowthroat likely breeds to some extent in salt marshes providing taller herbaceous vegetation (Ray 1919), as evidenced by the species' presence during the breeding season in such marshes (Santa Clara County Bird Data Unpublished; Santa Clara County Breeding Bird Atlas Committee Unpublished). Saltmarsh common yellowthroats also breed in the riparian corridor of Coyote Creek within the Study Area.

California Yellow Warbler (*Dendroica petechia brewsteri*); Federal Status: None; State Status: Species of Special Concern. The yellow warbler is a small songbird that breeds in well-developed riparian vegetation, and feed on insects. The yellow warbler is a migratory species that is common during migration, but migratory birds in California are mostly of one of the northern subspecies. Yellow warblers that remain to breed in northern and central California are of the race *D. p. brewsteri*. Due to a loss of riparian habitat in California over the last century, this subspecies is listed as a California Species of Special Concern. Most California yellow warblers migrate to Mexico and South America in the fall and return to California to breed from May through August. Yellow warblers are rare breeders in the Study Area, likely nesting only in the riparian corridor along lower Coyote Creek.

Alameda Song Sparrow (*Melospiza melodia pusillula*). Federal Listing Status: None; State Listing Status: Species of Special Concern. The Alameda song sparrow is one of three subspecies of song sparrow breeding only in salt marsh habitats in the San Francisco Bay area. Locally it is most abundant in the taller vegetation found along tidal sloughs, including salt marsh cordgrass and marsh gumplant. Populations of the Alameda song sparrow have declined due to the loss of salt marshes around the Bay, although within suitable habitat it is still fairly common. The location of the interface between populations of the Alameda song sparrow and those of the race breeding in freshwater riparian habitats (*M. m. gouldii*) along most creeks is not known due to difficulties in distinguishing individuals of these two races in the field.

In salt marshes, *pusillula* are most abundant in tall marsh vegetation, particularly in the marsh gumplant/California cord grass association immediately adjacent to tidal sloughs. *Pusillula* are also found in peppergrass in the upper, drier portions of salt marshes and occasionally in brackish marshes dominated by bulrushes (Marshall and Dedrick 1994). Except during very high tides, they make more limited use of the broad expanses of short pickleweed favored by savannah sparrows. Along several streams in the South Bay, song sparrows seem to be distributed continuously from the upper reaches down to tidal salt marsh. This distribution indicates that *gouldii* and *pusillula* come into contact along

these streams, probably at the interface of brackish and freshwater habitats, as Grinnell (1901) found at San Francisquito Creek.

Song sparrows nest as early as March, but peak nesting activity probably occurs in May and June. Salt marsh-breeding song sparrows in the Bay area (including *pusillula*) are known to breed about two weeks earlier than *gouldii* (Johnston 1954; Johnston 1956). This early breeding by *pusillula* is apparently an adaptation to breeding in a tidal environment, as high tides in late spring and early summer may destroy large numbers of nests.

Optimum habitat for this subspecies is tidal salt marsh, although it occurs in tidal brackish marsh, seasonal wetlands, salt pond complexes and other adjacent habitats. Alameda song sparrows occur commonly in suitable habitat throughout the South Bay, including the Shoreline Study Area, being particularly abundant in more extensive marshes but also occurring fairly commonly in narrower marshes along tidal sloughs as long as taller herbaceous vegetation for nesting is present.

Tricolored Blackbird (*Agelaius tricolor*). Federal listing status: None; State Listing Status: Species of Special Concern (nesting colony). Tricolored blackbirds are found almost exclusively in the Central Valley and central and southern coastal areas of California. This species was originally listed as a Species of Special Concern (at its nesting colonies) in California due to concerns over the loss of wetland habitats in the state. However, in 1992, surveys by the California Department of Fish and Game determined that the population of this species was much larger than previously believed (Beedy and Hamilton 1997), lessening concern for the species.

The tricolored blackbird is highly colonial in its nesting habits and forms dense breeding colonies, which in some Central Valley areas may consist of up to tens of thousands of pairs. This species typically nests in tall, dense, stands of cattails or tules, but also nests in blackberry, wild rose bushes and tall herbs. Nesting colonies are usually located near standing or flowing fresh water. Tricolored blackbirds form large, often multi-species, flocks during the non-breeding period and range more widely than during the reproductive season.

Appropriate breeding habitat for this species in the Shoreline Study Area is limited, and most breeding sites in the South Bay area are well inland from areas of tidal influence. This species nested in 1992 in ruderal habitat in the San Jose-Santa Clara Water Pollution Control Plant (Santa Clara County Breeding Bird Atlas Committee Unpublished), but no other breeding records are known from the immediate Study Area. Freshwater marshes providing fairly extensive stands of tules and cattails are present along upper Artesian, Alviso, and Guadalupe Sloughs, in the Warm Springs marshes, and along the Moffett Channel. However, the tricolored blackbird typically nests only in nontidal freshwater marshes, and it is therefore unlikely to use such tidal marshes for nesting.

Salt Marsh Wandering Shrew (*Sorex vagrans halicoetes*). Federal Listing Status: None; State Listing Status: Species of Special Concern. Formerly more widely distributed in the Bay area, this small insectivorous mammal is now confined to salt marshes of the South Bay (Findley 1955). Salt marsh wandering shrews occur most often in medium-high wet tidal marsh (six to eight feet above sea

level), with abundant driftwood and other debris for cover (Shellhammer 2000b). They have also been recorded occasionally in diked marsh. This species is typically found in fairly tall pickleweed, in which these shrews build nests. They breed and give birth during spring, although very little is known regarding the natural history of the species.

This subspecies was formerly recorded from marshes of San Pablo and San Francisco Bays in Alameda, Contra Costa, San Francisco, San Mateo, and Santa Clara Counties, but captures in recent decades have been very infrequent anywhere in these areas. Shrews are occasionally captured during salt marsh harvest mouse trapping studies (see Table 6 above), but the difficulty in identifying them to species has precluded a better understanding of the current distribution of this species in the South Bay. As of 1986, there were only four locations, including Bair Island, the Alameda Creek mouth, Dumbarton Point, and Mowry Slough, where this species had been positively identified between 1980 and 1985, although the species was considered likely present in a number of other marshes in the South Bay (Western Ecological Services Company (WESCO) 1986).

This species is likely present, albeit probably in low numbers, in extensive tidal salt marshes within the Shoreline Study Area. Much of the previous discussion of the habitat requirements of the salt marsh harvest mouse, such as extensive salt marsh with high-tide refugia, and of the effects of habitat fragmentation and barriers to dispersal, applies to the salt marsh wandering shrew as well.

Pacific Harbor Seal (*Phoca vitulina richardsi*). Federal Listing Status: None; State Listing Status: None. Pacific harbor seals are currently the only marine mammals that are permanent residents of San Francisco Bay. Although they are not listed by the state as a Species of Special Concern, harbor seals are protected under the federal Marine Mammal Protection Act, and are sensitive to human disturbance. NOAA Fisheries (the agency that oversees the protection of marine mammals) recommends a 100-yard disturbance-free buffer around harbor seals. Disturbance can lead to separation of pups from nursing mothers, can add physiological stress to adults, and can lead to long-term abandonment of historical haul-out sites (Lidicker and Ainley 2000).

Pacific harbor seals occur along the Pacific coast of North America from Alaska south to Baja California. In San Francisco Bay, they haul out at a number of sites to rest and pup (give birth). Most pupping occurs during spring, with a peak in April (Fancher and Alcorn 1982). Females nurse pups for about 28 days, during which time they are susceptible to being separated as a result of human disturbance. Haul-out sites are typically mudflats far from areas used regularly by humans, and near deeper water, where seals forage. Harbor seals forage in nearshore marine habitats on variety of fishes and invertebrates. Kopec and Harvey (1995) studied diet at several haul-out sites in 1991-1992, and found that in the South Bay, major diet items included yellowfin goby (*Acanthogobius flavimanus*), staghorn sculpin (*Leptocottus armatus*), and white croaker (*Genyonemus lineatus*).

More than ten sites around the Bay may be used by seals at any given time (Lidicker and Ainley 2000), and any undisturbed intertidal habitat accessible to the open Bay could potentially be used by harbor seals. Primary haul-out sites in San Francisco Bay are Mowry Slough (243 seals in 1999), Castro Rocks near the Richmond-San Rafael Bridge (107 seals in 1999), and Yerba Buena Island (72 seals in 1999);

(Lidicker and Ainley 2000). Mowry Slough, the most important site in the South Bay, produced 78 pups in 1999, 90 in 2000, 102 in 2001 and 144 in both 2002 and 2003 (Green et al. 2004); surveys in April 2004 found 283 seals, including 59 pups, at Mowry Slough and 34 seals, including nine pups, near the mouth of Coyote Creek at Calaveras Point (Bell Unpublished). At both these sites, mudflats and adjacent pickleweed marsh at various locations may be used at any particular time. Use of haul-out sites varies over time, and other South Bay sites, including Guadalupe Slough near the northeastern end of Pond A3N, the mouth of the Alameda Flood Control Channel, Newark Slough, Bair Island, and Greco Island are currently used or have been important haul-outs historically (Bell Unpublished; Fancher and Alcorn 1982; Kopec and Harvey 1995) (Figure 5).

4.4.3 Essential Fish Habitat

The Magnuson-Stevens Fishery Conservation and Management Act requires federal fishery management plans (FMPs) to describe the habitat essential to the fish being managed and describe threats to that habitat from both fishing and non-fishing activities. In addition, in order to protect this Essential Fish Habitat (EFH), federal agencies are required to consult with NOAA Fisheries on activities that may adversely affect EFH.

The Shoreline Study Area includes EFH from three FMPs, the Coastal Pelagic, West Coast Groundfish, and Pacific Coast Salmon FMPs. Fish species covered under these plans that occur in the South Bay are listed in Table 10.

Table 10 - Fisheries Management Plan (FMP) species in the South Bay

Common Name	Scientific Name	Occurrence
Coastal Pelagic FMP		
Northern anchovy	<i>Engraulis mordax</i>	Abundant from South to Central Bay; adults and juveniles present in South and South-Central Bay, adults, juveniles, larvae, and eggs present in Central Bay
Pacific sardine	<i>Sardinops sagax</i>	Present in South and South-central Bay and rare in Central Bay; adults and juveniles present
Jack mackerel	<i>Trachurus symmetricus</i>	Present in Central Bay; eggs and larvae
Pacific Groundfish FMP (Estuarine Composite EFH)		
Leopard shark	<i>Triakis semifasciata</i>	Present from South Bay to Central Bay; adults and juveniles present
Soupfin shark	<i>Galeorhinus galeus</i>	Present in South-central and Central Bay and rare in South Bay; adults and juveniles present in Central Bay and rare in South Bay, less known about life stages in South-central Bay
Spiny dogfish	<i>Squalus acanthias</i>	Present from South Bay to Central Bay; adults and juveniles in South and Central Bay, less known about life stages in South-central Bay
Big skate	<i>Raja binoculata</i>	Present from South Bay to Central Bay; adults and juveniles present in Central Bay, less known about other life stages present in South and South-central Bay

Common Name	Scientific Name	Occurrence
California skate	<i>Raja inornata</i>	Present in South Bay (probably rare)
Lingcod	<i>Ophiodon elongatus</i>	Present from South to Central Bay but rare in South-central Bay; adults and juveniles present in Central Bay, less known about life stages present in South Bay
Kelp greenling	<i>Hexagrammos decagrammus</i>	Present in Central Bay; juveniles and adults
Pacific whiting (hake)	<i>Merluccius productus</i>	Present in Central Bay; eggs and larvae
Brown rockfish	<i>Sebastes auriculatus</i>	Present from South to Central Bay; juveniles present in South and South-Central Bay, adults and juveniles present in Central Bay
Curlfin sole	<i>Pleuronichthys decurrens</i>	Present in Central Bay; juveniles
English sole	<i>Parophrys vetulus</i>	Abundant from South to Central Bay; adults and juveniles present
Pacific sanddab	<i>Cintharichthys sordidus</i>	Present from South to Central Bay; adults, juvenile, larvae, and eggs present in Central Bay, less known about life stages in South Bay
Sand sole	<i>Psettichthys melanostictus</i>	Present in South and Central Bay but rare in South-central Bay; adults, juveniles, and larvae present
Starry flounder	<i>Platichthys stellatus</i>	Present from South to South-central Bay and abundant in Central Bay; adults and juveniles present in South Bay and adults juveniles, larvae, and eggs present in Central Bay
Cabazon	<i>Scorpaenichthys marmoratus</i>	Rare to few from South to Central Bay; juveniles present in South and South-Central Bay, adults and juveniles present in Central Bay
Bocaccio	<i>Sebastes paucispinis</i>	Rare in Central Bay, less known about presence and life stages elsewhere in Bay
Calico rockfish	<i>Sebastes dalli</i>	Rare in South Bay, life stages unknown
Rex sole	<i>Glyptocephalus zachirus</i>	Rare in South Bay, life stages unknown
Pacific Coast Salmon FMP (Estuarine Composite EFH)		
Chinook salmon Central Valley fall- and late fall-run ESU	<i>Oncorhynchus tshawytscha</i>	Spawns in several South Bay streams, including Coyote Creek and the Guadalupe River

The Magnuson-Stevens Act defines EFH as “those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity.” For the Pacific Coast Salmon FMP, the EFH includes freshwater and marine habitats, including habitats for estuarine and ocean rearing and juvenile and adult migration. The important features of EFH include “1) adequate water quality; 2) adequate temperature; 3) adequate prey species and forage base (food); and 4) adequate depth, cover, marine vegetation, and algae in estuarine and near-shore habitats.” For the Coastal Pelagic Species FMP, the EFH includes “all marine and estuarine waters from the shoreline along the coasts of California, Oregon and Washington offshore to the limits of the Exclusive Economic Zone (EEZ) and above the thermocline where sea surface temperatures range between ten and 26 degrees C.” For the West Coast Groundfish FMP, seven “composite” EFH categories are defined. The estuarine composite includes:

“...those waters substrates and associated biological communities within bays and estuaries of the coasts of Washington, Oregon, and California, seaward from the high tide line (MHHW) or extent of upriver saltwater intrusion. These areas are delineated from the USFWS National Wetland Inventory (NWI) and supplemented from NOAA’s Coastal Assessment Framework for the water portion of the Estuarine Drainage Areas for two small estuaries (Klamath River and Rogue River), the Columbia River, and San Francisco Bay. NWI defines estuaries as areas with water greater than 0.5 ppt ocean-derived salt.”

Thus, all marine areas within the Study Area below MHHW with salinity of 0.5 ppt or greater are considered EFH.

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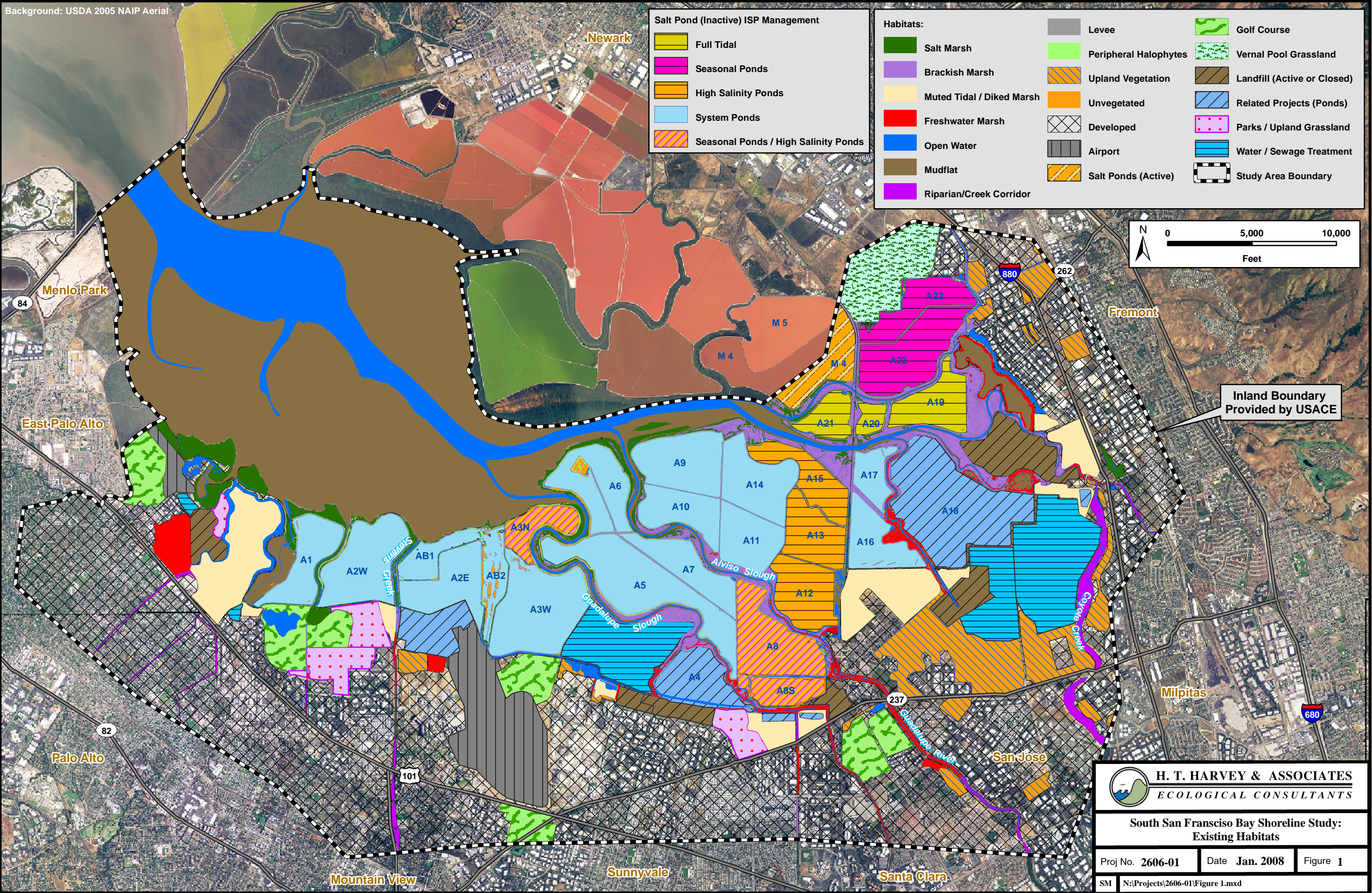
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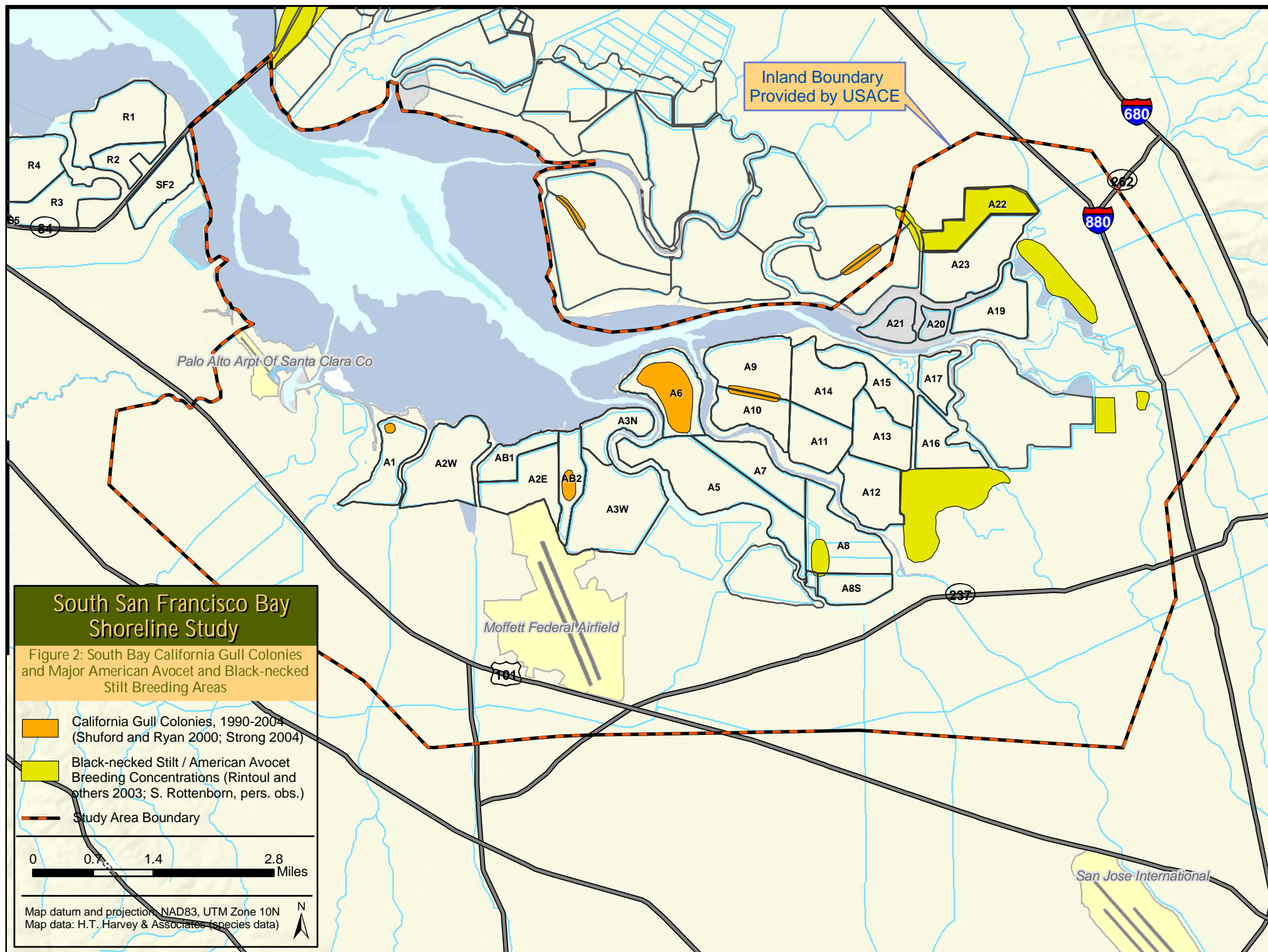
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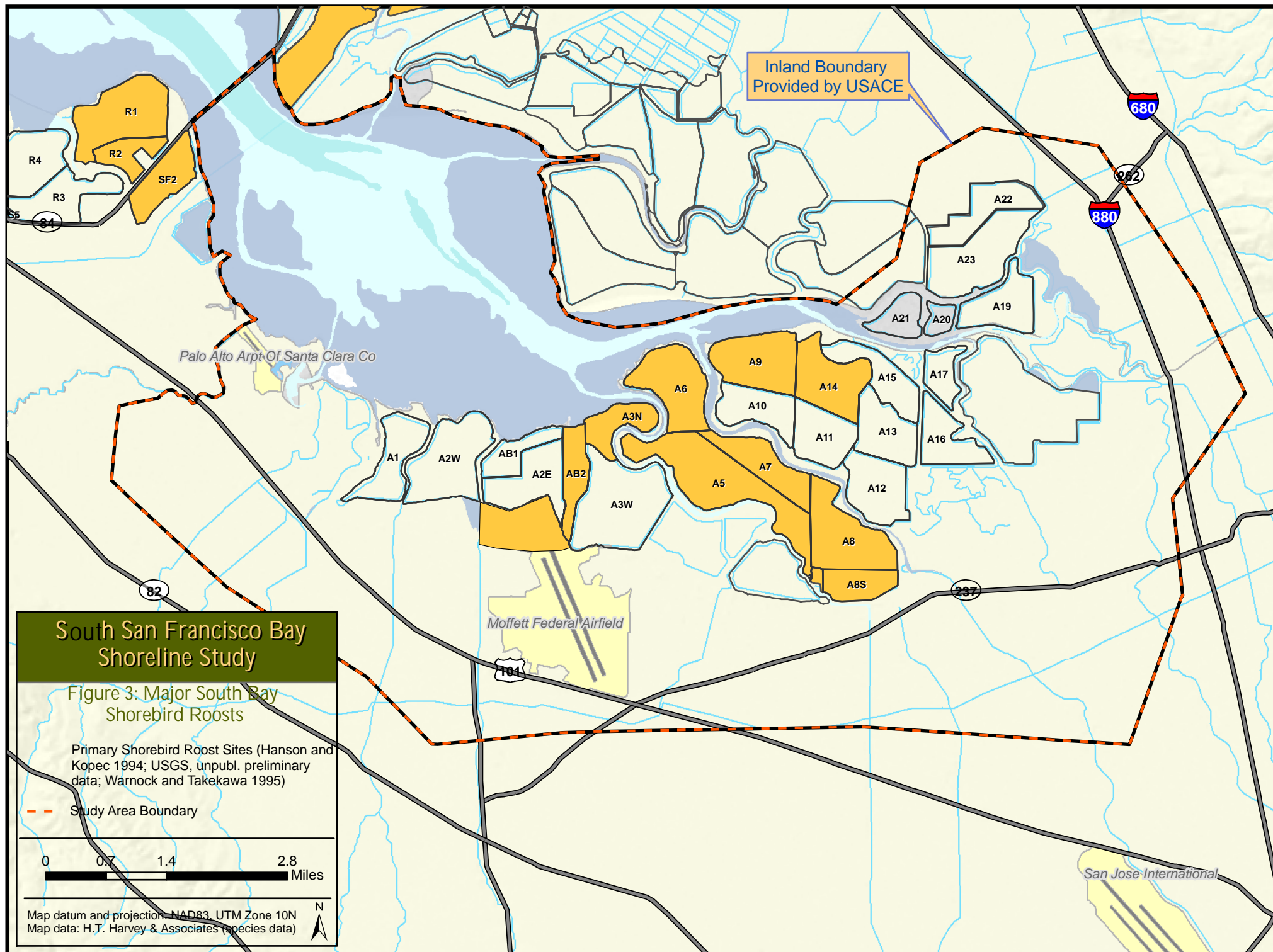
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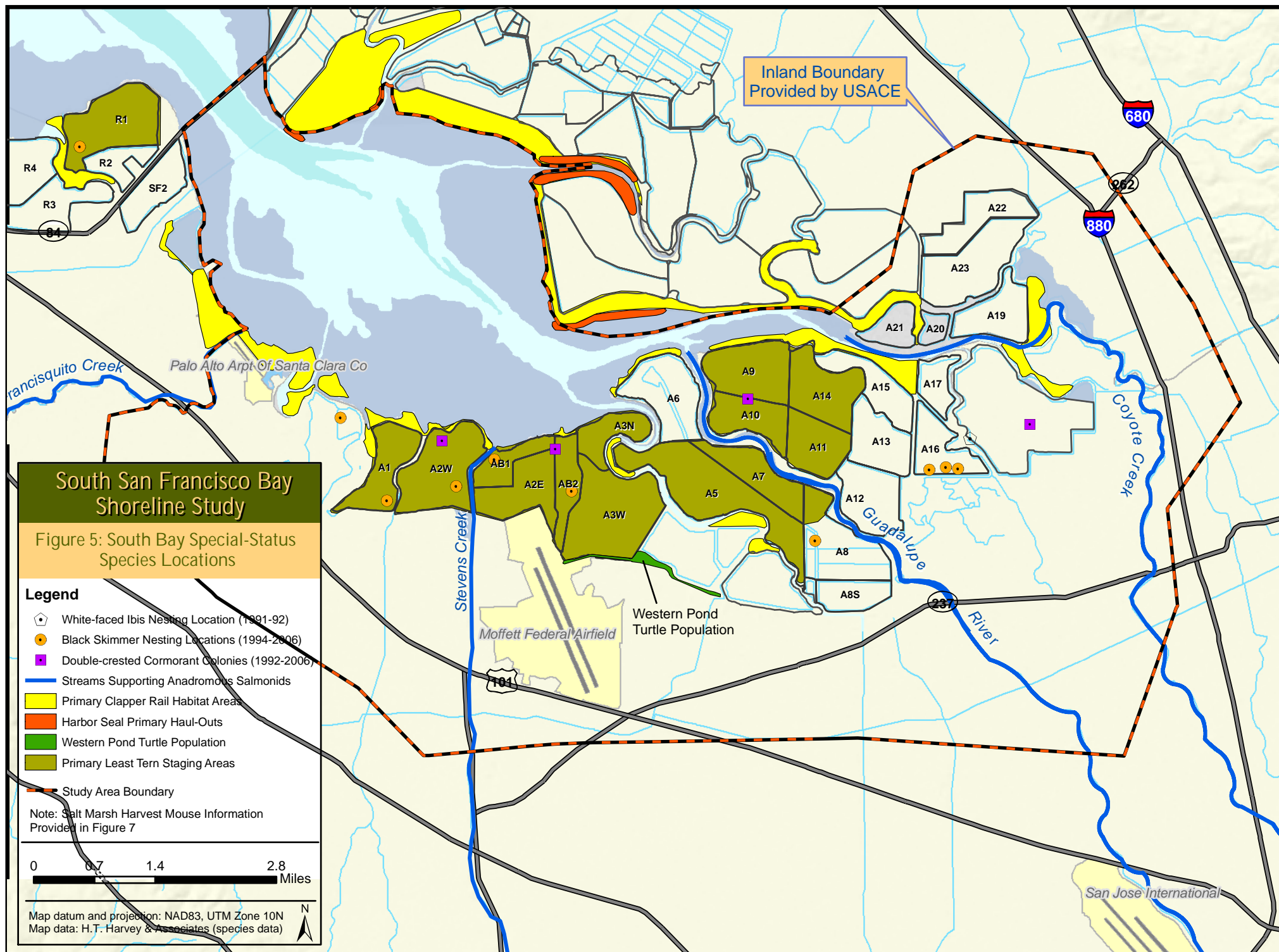
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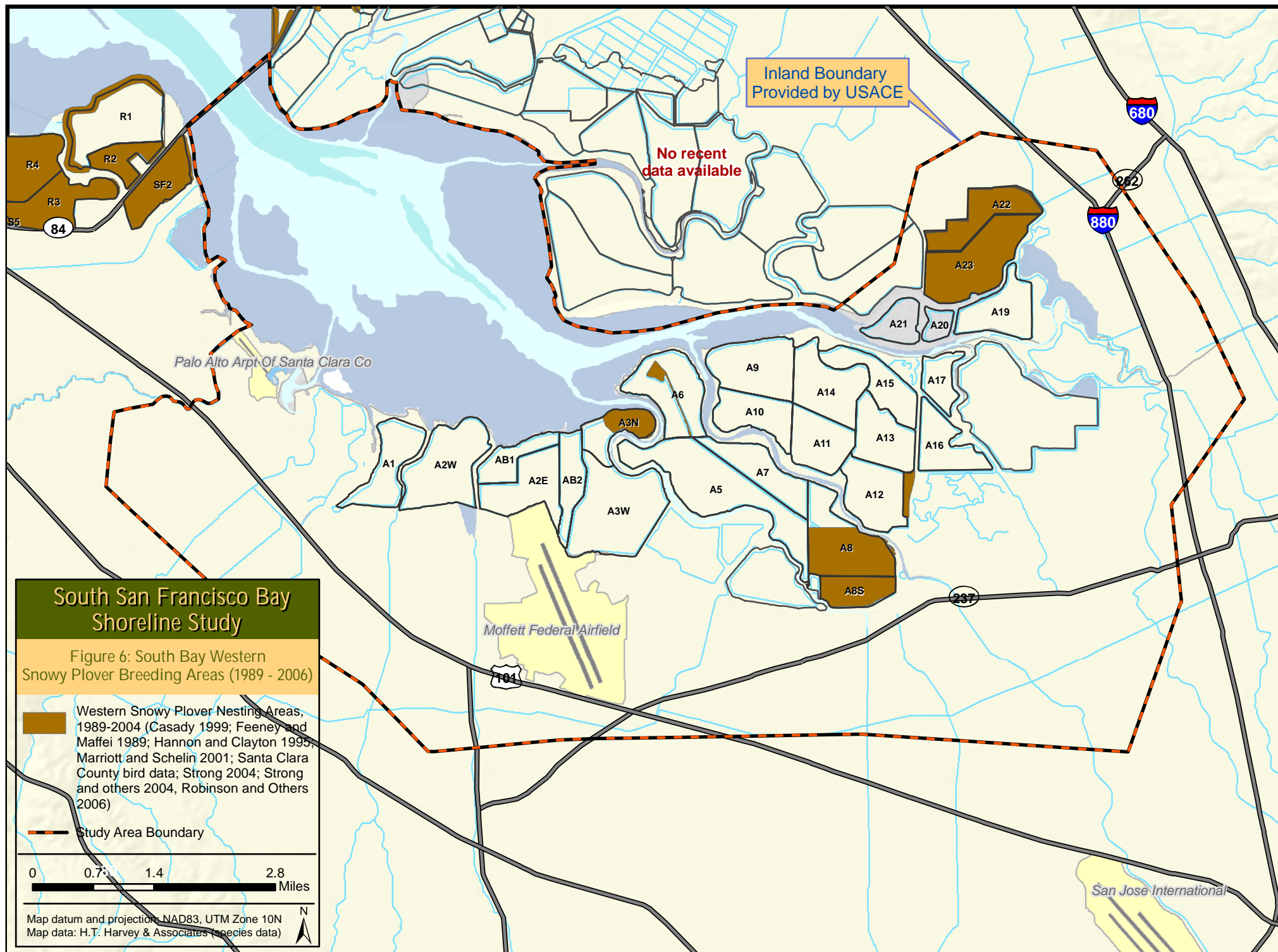
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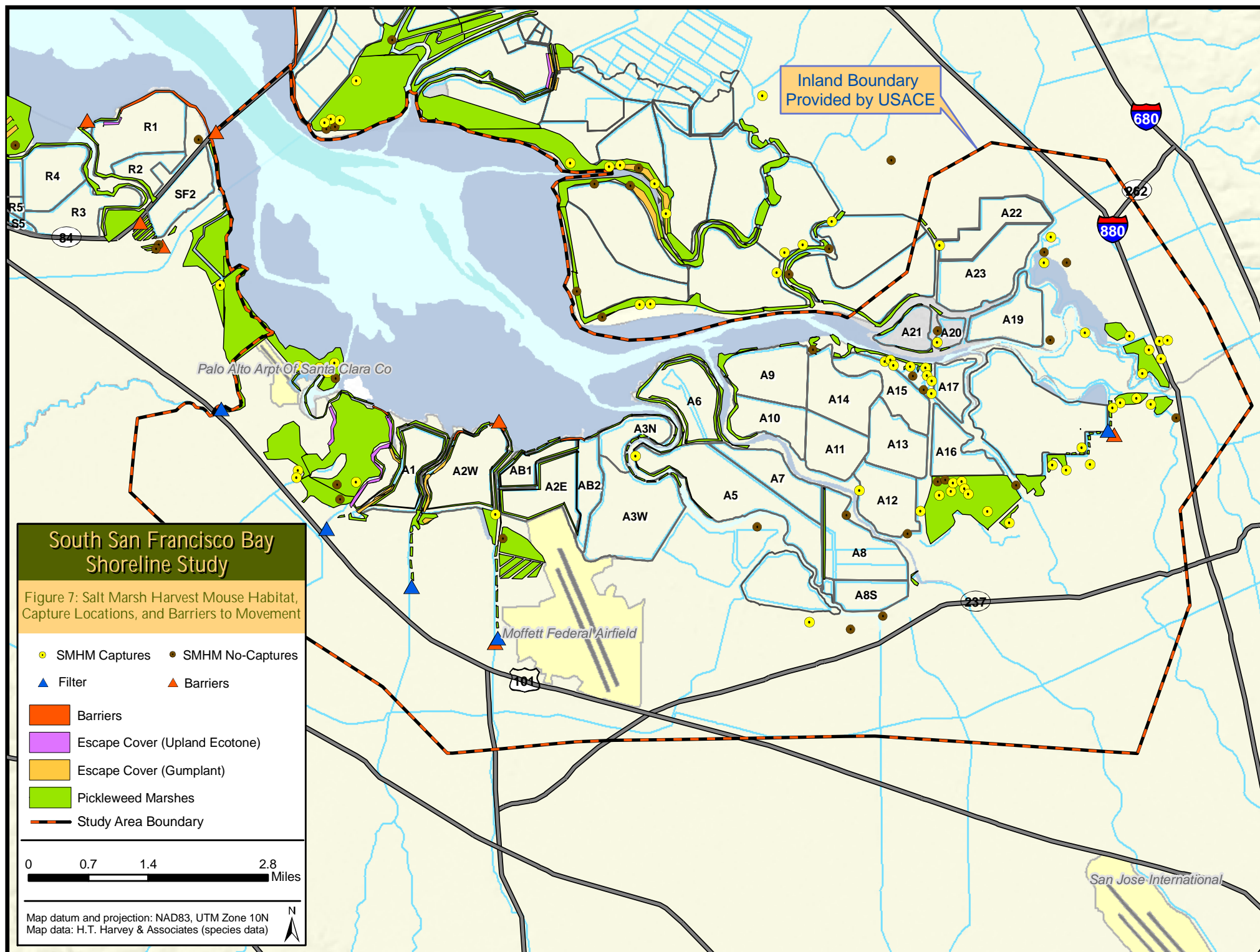


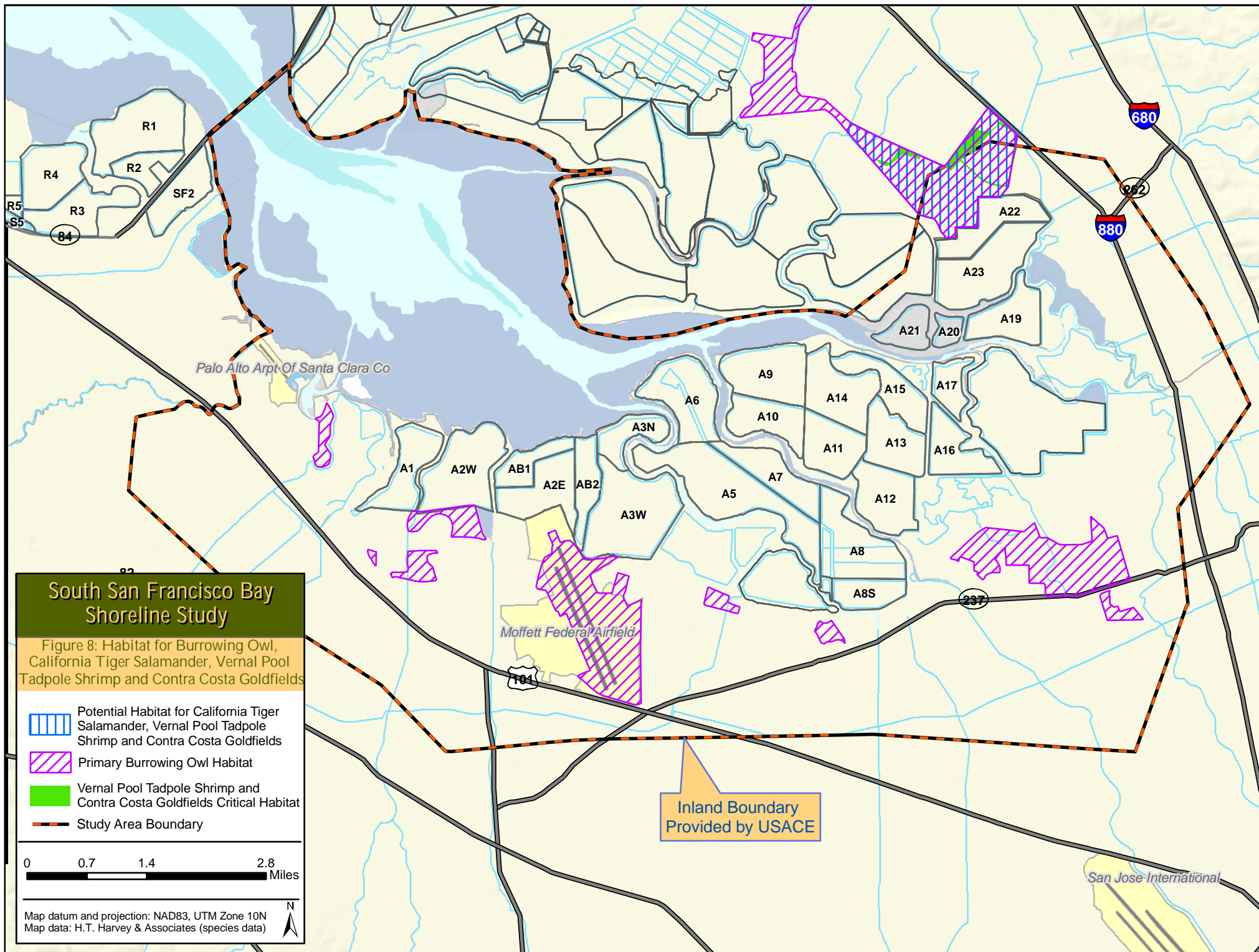












Appendix A.
Special-Status Species Regulations Overview

Overview. Federal and state endangered species legislation gives special status to several plant and animal species known to occur in the vicinity of the Study Area. In addition, state resource agencies and professional organizations, whose lists are recognized by agencies when reviewing environmental documents, have identified as sensitive some species occurring in the vicinity of the Study Area. Such species are referred to collectively as “species of special status” and include plants and animals that are listed, proposed for listing, and candidates for listing as threatened or endangered under the federal Endangered Species Act (ESA) or the California Endangered Species Act (CESA); animals listed as “fully protected” under the California Fish and Game Code; animals designated as “Species of Special Concern” by the CDFG; and plants listed as rare or endangered by the California Native Plant Society (CNPS) in the *Inventory of Rare and Endangered Plants of California* (2001).

ESA provisions protect federally listed threatened and endangered species and their habitats from unlawful take. Under the ESA, to “take” is “to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any of the specifically enumerated conduct.” The U.S. Fish & Wildlife Service’s (USFWS) regulations define harm as “an act which actually kills or injures wildlife.” Such an act “may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding or sheltering” (50 CFR § 17.3). Activities that may result in “take” of individuals are regulated by the USFWS. The USFWS produced an updated list of candidate species May 11, 2005 (50 CFR Part 17). Candidate species are not afforded any legal protection under ESA; however, candidate species typically receive special attention from federal and state agencies during the environmental review process.

Provisions of CESA protect state-listed threatened and endangered species. CDFG regulates activities that may result in “take” of individuals (*i.e.*, “hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch, capture, or kill”). Habitat degradation or modification is not expressly included in the definition of “take” under the California Fish and Game Code. Additionally, the California Fish and Game Code contains lists of vertebrate species designated as “fully protected” (California Fish & Game Code §§ 3511 [birds], 4700 [mammals], 5050 [reptiles and amphibians], 5515 [fish]). Such species may not be taken or possessed.

In addition to federal and state-listed species, the CDFG also has produced a list of Species of Special Concern to serve as a watch list. Species on this list are of limited distribution or the extent of their habitats has been reduced substantially, such that threat to their populations may be imminent. Species of Special Concern may receive special attention during environmental review, but they do not have statutory protection. USFWS also uses the label “Species of Special Concern” as an informal term that refers to those species that might be in need of concentrated conservation actions. Species of Special Concern receive no legal protection as a result of their designation as Species of Special Concern, and the use of the term does not necessarily mean that the species will eventually be proposed for listing as a threatened or endangered species. However, most, if not all, of these species are currently protected by state and federal laws.

Vascular plants listed as rare or endangered by the CNPS, but which might not have designated status under state endangered species legislation, are defined as follows:

- List 1A Plants considered by the CNPS to be extinct in California.
- List 1B Plants rare, threatened, or endangered in California and elsewhere.
- List 2 Plants rare, threatened, or endangered in California, but more numerous elsewhere.
- List 3 Plants about which more information is needed – a review list.